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SECTION 211300 – FIRE SUPPRESSION SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division – 1 Specification Sections, apply to work specified in this section.

1.02 GENERAL DESCRIPTION OF WORK

The Contractor shall design, install and test the feed main and sprinkler systems throughout the Readiness Center addition. The work included under this section will begin at a 6-inch blind flange at the Phase 3A valve station.

The major items of the scope of work include, but are not limited to the following:

1. Provide and install fire protection water supply piping from the valve station in Phase 3A to a new valve station in the Readiness Center addition.
2. Provide a sprinkler zone for each floor.
3. Provide a sub-zone for the elevator hoistway and elevator control room (Alternate No. 1)
4. Layout, provide and install sprinkler systems throughout the Readiness Center addition as noted.
5. Label all pipe in accordance with DOD Standards.

Details concerning all work required for the project follows in the specifications and are shown on the Contract Drawings.

1.03 CONTRACT DRAWINGS

The Fire Suppression System Arrangement Drawings included with these specifications are utilized to illustrate the general locations of the new and existing major components and system boundaries of the fire suppression systems. See Paragraph 1.10 (System Arrangement and Design) for information regarding background and supplemental drawings.

The drawings are as follows:

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1.04 CODE REQUIREMENTS

FIRE SUPPRESSION SYSTEMS
Fire protection system design, layout, materials, manufacture, installation, examination, testing, inspection, stamping certifications, and documentation shall conform to applicable portions of the following adopted codes, standards, and all addenda thereto.

**UNIFIED FACILITIES CRITERIA (UFC)**

UFC 3-600-01  FIRE PROTECTION ENGINEERING FOR FACILITIES (2018)

NATIONAL FIRE PROTECTION ASSOCIATION

No. 72 - National Fire Alarm Code (2019)

These specifications are based upon the latest national standards and codes in force at the time of issue of these documents. Any conflict between referenced standards shall be referred to the Engineer who will determine which standard shall govern. The Owner shall be the Authority Having Jurisdiction over the interpretation of codes and standards. All correspondence requiring decision by the Authority shall be directed through the Engineer for resolution. The requirements of these specifications and associated drawings take precedence over the minimum requirements of the Codes and Standards listed above.

1.05 **LISTINGS AND APPROVALS**

All equipment and devices furnished under these specifications shall be Factory Mutual (FM) Approved or Underwriters Laboratories (UL) Listed unless specifically noted otherwise. Approved or Listed equipment shall be so noted in the latest edition of the FM Approval Guide (P7825a) or the UL Fire Protection Equipment Directory.

1.06 **CONTRACTOR'S QUALIFICATIONS**

This section covers the technical qualifications required for the Contractor's technical, layout and installation personnel. Proposed personnel shall be subject to the Owner's approval.

1.06.1 **Contractor**

Installation shall be performed by a Fire Protection Contractor who is experienced in the layout and installation of fire protection systems (minimum five (5) years). Additionally, the Contractor shall have successfully installed fire protection systems of the same type and layout as specified herein. The Contractor shall submit, with the bid, the names and locations of at least two installations where the Contractor has installed such systems. The Contractor shall certify that each system has performed satisfactorily for a period of not less than two years.

1.06.2 **Technician**

Piping layout and hydraulic calculations shall be performed by a NICET Level III or IV Technician (Sprinkler Systems Subfield of Fire Protection Engineering Technology), Registered Fire Protection Engineer, or a Registered Professional Engineer with at least two years of experience in fire protection layout. Engineers shall be licensed in the State of Missouri.

1.06.3 **Installation Supervisor**
The Contractor’s installation supervisor(s) shall have at least five years of experience in sprinkler system installation, technically competent, trained, and experienced in the installation and operation of the equipment under their jurisdiction. The supervisor shall be on the job site during the entire installation.

1.07 DOCUMENT SUBMITTALS

Document submittals shall be in accordance with SECTION 013304 and this section. The Contractor shall submit the documents electronically, for review, to the Engineer prior to the start of fabrication or installation. The Contractor shall upload the submittal to the Engineer. The submittal shall include required information for all work included in this section. Documents shall be fully completed and certified by the Contractor as to the compliance of the information contained therein with the requirements of the contract documents. Incomplete submittals will not be reviewed. Complete submittals will be reviewed by the Engineer and processed as specified in Division 1. The Engineer's review will be for general conformity to the specified requirements and is not intended to constitute detailed review or approval of content. Documents stamped ACCEPTED do not relieve the Contractor from any contract requirements.

All drawings shall be prepared in Revit (2019) or (AutoCAD (Version 2010 or later). Drawings and data shall be in sufficient detail to indicate the kind, size, arrangement, and operation of component devices; the external connections, anchorages, and supports required; and dimensions needed for installation and correlation with other equipment. All drawings shall be to a standard architectural scale which shall be noted on the drawings (including Graphic Representation). Drawing size shall not be less than 30 inches by 42 inches or greater than 34 inches by 44 inches.

All Equipment and Material Data Sheets shall be submitted as a single PDF document. The document shall include bookmarks for each product submitted. Calculations shall be submitted as individual PDF files. Drawings shall be submitted as individual full-size PDF files. A separate transmittal PDF file shall be included. The drawings and calculations shall have a certification sheet bearing the NICET designer certification or the seal of the Contractor’s registered professional engineer. All file names shall describe the file content. The transmittal shall also include the specification title, the specification number, and the Contractor’s name.

1.07.1 Documents Required

The following documents shall be submitted for this project:

1.07.1.1 Equipment and Material Data Sheets

Equipment data sheets shall be submitted for all equipment and devices used in the systems. If options are listed on the data sheets, the specific option for the project shall be clearly marked. The data sheet submittal shall include, but not be limited to the following:

1. Sprinkler System Valves – Documents shall include data sheets and instruction manuals.

2. Isolation Valves

3. Sprinklers

4. Pipe – If more than one pipe type is used, the sheets shall be marked to indicate the application of each type.
5. Pipe Supports and Hanger Assemblies – Hanger assembly drawings (hanger, rod, structure attachment, etc.) are required for each assembly type used on the project.

6. Waterflow or alarm pressure switches, other supervisory air switches and valve tamper switches.

Other installation related materials to be submitted with the sprinkler system documents are as follows:

1. Firestopping materials

1.07.1.2 Piping Drawings

Piping drawings shall show all piping, devices, and information necessary for the complete installation. The drawings shall be plotted in a standard architectural scale.

The drawings shall include the following items:

1. Name of owner and occupant.
2. Specification title and number.
3. Contractor’s name and address.
4. Location, including street address.
5. Point of compass.
6. Full height cross section, or schematic diagram, including ceiling construction.
7. Location of partitions.
8. Location of fire rated barriers or walls and smoke barriers.
9. Locations of lights, diffusers, equipment, large piping, etc. located near the sprinklers or in other locations that could be obstructions to sprinkler discharge.
10. Location of unit heaters and direction of air flow.
11. Any concealed spaces in which no sprinklers are to be installed.
12. Size of site main and distance to fire pump.
13. Fire pump rating and test information.
14. Make, type, temperature rating, and nominal orifice size of sprinklers.
15. Number of sprinklers on each sprinkler system.
16. Pipe type and schedule of wall thickness.
17. Nominal pipe size and cutting lengths of pipe (or center to center dimensions). Where typical branch lines prevail, it will be necessary to size only one typical line.
18. Location, size and length of riser nipples.
19. Type of fittings and joints and location of all welds and bends. The Contractor shall identify on drawing any sections to be shop welded and the type of fittings or formations to be used.
20. Type and locations of hangers, sleeves and braces.
21. All control valves and check valves.
22. All main drains, low point drains and inspector’s test connections. All piping associated with drains shall be shown.
23. Underground pipe size, length, location, weight, material, point of connection to the site main; the type of valves, meters, and valve pits; and
1.07.1.3 Hydraulic Calculations

Hydraulic calculations shall be submitted for each sprinkler and water supply piping system in accordance with NFPA 13. Calculations shall include all piping back to the tested water supply. The Contractor shall submit a dimensioned sketch showing pipe sizes, lengths, fittings and hydraulic node points for any piping in calculations that are not shown on the Contractor’s shop drawings. This sketch shall be attached to the calculations or included on the shop drawings.

The fire pump flow test data from the tests required to be obtained from the Owner shall be submitted with the hydraulic calculations.

1.07.2 Document Disposition

1.07.2.1 The reviewed documents will be returned, in one of the following ways:

a. ACCEPTED
b. ACCEPTED WITH COMMENTS NOTED
c. ACCEPTED WITH COMMENTS NOTED – RESUBMITTAL REQUIRED
d. REJECTED

1.07.2.2 When the documents are returned marked ACCEPTED, the Contractor is released to begin fabrication and installation.

1.07.2.3 When the documents are returned marked ACCEPTED WITH COMMENTS NOTED, the Contractor shall make the noted changes and is released to begin fabrication and installation. The changes do not need to be resubmitted until the Record Document markups are submitted. Record Document markups shall have the revisions backcircled.

1.07.2.4 When the documents are returned ACCEPTED WITH COMMENTS NOTED – RESUBMITTAL REQUIRED, the basic design is accepted, however, the Contractor is not released to fabricate or begin installation. A complete resubmittal is required (all documents) unless specifically noted otherwise. All revisions shall be backcircled. The NICET Certification or Engineer’s seal (See Paragraph 1.06) is required on the resubmittal.

1.07.2.5 When the documents are returned REJECTED, the Contractor shall redesign based on the comments and resubmit. All revisions shall be backcircled. The NICET Certification or Engineer’s seal (See Paragraph 1.06) is required on the resubmittal.
1.07.2.6 Resubmittals will not be reviewed without a correction or response for each review comment (backcircled).

1.08 FINAL DOCUMENTATION

The Installation, Operation, and Maintenance Manual shall be submitted for review with the red line drawings. Final copies of the Installation, Operation, and Maintenance Manual (with all drawings) are required within three (3) weeks after the final acceptance test.

Marked up shop drawings (red-lines) and Record Drawings shall be submitted. Red-lines shall be submitted prior to the acceptance test. The Record Drawings are required to be submitted to the Engineer within two (2) weeks after the acceptance test.

All submittals shall be electronic, in the form and arrangement of the original document submittals. After acceptance of all documents, one hard copy shall be distributed to the Owner (Drawings shall be rolled). A CD or DVD shall accompany the hard copy. The electronic copy shall include a single PDF file of the Installation, Operation, and Maintenance Manual (except the NFPA document). The files shall be bookmarked for each item. Drawings shall be included as individual full-size PDF files and individual bound AutoCAD files. A copy of the CD or DVD shall be forwarded to the Engineer.

The following documents shall be included in the final documentation:

1.08.1 Installation, Operation and Maintenance Manual

A complete Installation, Operation and Maintenance Manual shall be furnished for the suppression systems. The hard copy of the manual shall be assembled and bound in a durable binder. The manual shall be permanently labeled with at least the project name, project number and date of completion. The following items shall be included in the manual as necessary:

1. Table of Contents
2. Index Tabs for each section
3. Contractor’s name, address, telephone number, 24-hour emergency number and Service Manager’s name
4. Equipment and Material Data Sheets (See specific requirements below)
5. Installation instructions for all equipment
6. Maintenance instructions for all equipment
7. Assembly drawings
8. Fire Pump Data (See Paragraph 1.07)
9. Hydraulic Calculations (See specific requirements below)
10. Fire pump test data
11. Parts lists
12. List of acceptable lubricants
13. Nameplate information and shop order numbers for each item of equipment and component part thereof
14. List of recommended repair parts
15. List of maintenance tools furnished with the equipment
16. Record Drawings, calculations and equipment data sheets (See specific requirements below)
17. Properly completed Contractor’s Materials and Test Certificate(s) for Above Ground Piping.
18. Contractor’s Warranty Document

The above listed requirements are minimums. Additional information, which is necessary for proper operation and care of the equipment, shall be included. Requirements which are clearly not applicable to the equipment may be deleted.

1.08.2 Record Drawings

The record final drawings shall be prepared in Revit or AutoCAD. The Record Drawings (hard copy) shall be certified by the NICET Technician or sealed by the Contractor’s Professional Engineer.

The information on the shop drawings shall be modified to show the final condition of the sprinkler system. Modifications shall include, but not be limited to, the following items:

1. All sprinklers, piping and other components shall be shown in their actual locations. Notations regarding re-use or relocation of components shall be removed.
2. Components removed during construction shall be removed from drawings.
3. General notes, keyed notes and other notations on drawings explaining work to be performed during construction shall be removed.
4. Detail drawings shall be modified to reflect final conditions.
5. The revision block shall show a revised date and indicate that the revision is the Record Documents.

Additional drawings shall be developed where needed to accurately document final conditions.

1.08.3 Equipment Data Sheets and Calculations

Equipment data sheets shall be updated if necessary due to any approved equipment substitutions or review comments and submitted in a clearly marked section of the Instruction Manual.

Calculations shall be revised due to any modified conditions or review comments and submitted in a clearly marked section of the Manual. The final calculations (hard copy) shall be certified by the NICET Technician or sealed by the Contractor’s Professional Engineer.

1.09 WATER SUPPLY

The water supply at this facility consists of the two 2,000 gpm at 125 psi fire pumps drafting a 200,000 gallon reservoir. A 12-inch PVC looped main extends around the building. A 12-inch feed main extends to the existing valve station where this work scope begins. The Contractor shall obtain the existing site drawings from the Owner.

The Contractor shall submit the results of the latest annual fire pump test(s) (performed by others) with the suppression system shop drawings. The test documentation shall include a Contractor provided location sketch to illustrate the locations of the fire pump, relative to the valve station.
1.10 SYSTEM ARRANGEMENT AND DESIGN

1.10.1 Reference and Background Drawings

The Owner will make available, upon request, existing site civil drawings for Contractor review and incorporation into the design. The Contractor shall be responsible to determine the accuracy of existing documents and perform detailed design based on actual conditions. The Fire Protection Arrangement Drawings included in this contract illustrate a conceptual arrangement of major equipment and the existing valve station and minimum piping sizes. The Contractor shall notify the Engineer of any code compliance issues involved with the layout and shall be responsible to perform the detailed layout based on the resolution of the issue at no additional cost to the Owner. Electronic copies of the contract background drawings will also be made available to the Contractor upon request.

The work shall begin at a flat faced flange on the existing valve station, in the existing building, near the southwest corner of the addition.

The new sprinkler system risers shall be located in the mechanical room as shown on the contract drawings.

1.10.2 Hydraulic Design

All systems shall be hydraulically calculated. The design shall be based on the density-area method. The most remote area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area of sprinkler operation used. Each system shall be sized to provide a 10 percent pressure margin at the required flow.

A 12-inch PVC loop is located around the perimeter of the overall building. For the purpose of creating hydraulic calculations, the Contractor shall assume that the shortest leg of the loop to the specific suppression system is impaired and flow water through the longest route. Additionally, only one of the two pumps (lowest performance) shall be used for the supply.

The Occupancy Classification for each area of the building is outlined on the Fire Protection Arrangement Drawings. Sprinkler design densities, system coverage and some specific sprinkler temperature ratings for the various areas of the building are included. Detailed requirements follow.

Required sprinkler densities, area of operation, flows and spacing’s, based on the Occupancy classification are as follows:

1. Areas identified as Light Hazard Occupancies shall be designed for an end head density of 0.10 gpm/sq. ft. (4.1 (L/min)/m²) over the hydraulically most remote 1,500 sq. ft. (139 m²) area. Sprinkler spacing shall not exceed 225 square feet (20.9 m²). The calculated demand shall include 100 gpm (379 L/min) for outside hose streams.

2. Areas identified as Ordinary Hazard, Group 1 Occupancies shall be designed for an end head density of 0.12 gpm/sq. ft. (4.9 (L/min)/m²) over the hydraulically most remote 3,000 sq. ft. (279 m²) area. Sprinkler spacing shall not exceed 130 square feet (12.1 m²). The calculated demand shall include 250 gpm (946 L/min) for outside hose streams.

3. Areas identified as Ordinary Hazard, Group 2 Occupancies shall be designed for an end head density of 0.17 gpm/sq. ft. (6.9 (L/min)/m²) over the hydraulically most remote 3,000
sq. ft. (279 m²) area. Sprinkler spacing shall not exceed 130 square feet (12.1 m²). The calculated demand shall include 250 gpm (946 L/min) for outside hose streams.

Reductions in densities or areas below these stated above, based on NFPA 13 allowances, are not allowed.

1.10.3 Sprinkler Placement and Requirements

Sprinklers in areas with finished ceilings, not specifically located on the contract drawings, shall be arranged with consideration to the architectural features of the building. Sprinklers shall be evenly spaced out, in line with other sprinklers and centered on ceiling tiles, beams and other building features. The layout chosen is subject to the acceptance of the Engineer.

Specific locations of sprinklers in architecturally sensitive areas have been shown on the fire suppression arrangement drawings. These layouts shall be followed unless they violate any NFPA 13 requirements. The Contractor shall notify the Engineer of any code compliance issues involved with the layout and shall be responsible to correct any deficiencies at no additional cost to the Owner.

Sprinklers shall be located in special locations as identified below unless local requirements are more stringent:

1. Stairwells – Sprinklers shall be located at the top of all stairwell shafts (full shaft area protection) and below the bottom landing (if accessible).

2. Coolers, Refrigerators and Freezers – Dry pendant sprinklers shall be provided in all walk-in coolers, refrigerators and freezers.

Specific locations where sprinkler guards are required are as follows:

a. Elevator hoistway (Alternate No. 1)

1.10.4 Painting/Identification

Sprinkler piping shall be labeled per UFC 3-600-01 requirements.

1.11 WARRANTY

All equipment, materials and installation shall be warranted by the Contractor during construction and for a period of two (2) years beginning at the conclusion of the acceptance test. Response to service calls shall be within eight (8) hours of notification of system trouble or two (2) hours on emergencies. Repairs shall be completed within 48 hours of notification. The Contractor shall show how they will provide this capability and furnish the Owner with a 24-hour service call number.
PART 2 – PRODUCTS

2.01 GENERAL

2.01.1 Materials

Products (equipment) shall be furnished as outlined in the following subsections. Unless specifically noted otherwise, all materials and equipment furnished for permanent installation in the work shall conform to applicable standard specifications and shall be new, unused, and undamaged.

Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate equipment shall be of the same manufacturer and interchangeable.

All equipment and material furnished for incorporation into the work shall be asbestos free.

2.01.2 Listings and Approvals

All equipment furnished under these specifications shall be Factory Mutual (FM) Approved or Underwriters Laboratories (UL) Listed for the intended use unless specifically noted otherwise.

2.02 VALVES – SPRINKLER SYSTEM AND VALVE STATION ISOLATION

FM Approved iron body bronze mounted gate valves of the OS&Y type, having flanged or grooved ends, shall be furnished and installed. Automatic sprinkler system or zone isolation valves may be FM Approved butterfly valves with integral valve tamper switches.

2.03 CHECK VALVES

Check valves shall meet the requirements of NFPA 13 and shall be UL Listed and/or FM Approved for the intended uses. Swing check valves shall be used for all main supply piping.

2.04 SPRINKLER SYSTEM VALVES

A valve station consisting of an isolation valve, check valve, 2-inch drain valve, water pressure gauge, inspector’s test valve and sight glass, waterflow switch and valve tamper switch shall be provided for each wet pipe sprinkler system as shown on the arrangement drawings.

The fire protection sprinkler system valves (including system control valve, main drain valve, and test valve) shall be properly identified. All valves shall be identified as to their use and if they are normally open or closed. A permanently attached hydraulic design information sign shall be provided at each system valve, indicating the location of the protected area and all hydraulic information as required by NFPA for the particular system.

2.05 SPRINKLERS/STORAGE CABINET

Sprinklers in areas with finished ceilings shall be quick response semi-recessed, chrome pendant, glass bulb types rated for the ordinary temperature range, unless specifically noted otherwise on the fire protection drawings or needing to be a higher range to comply with NFPA 13 requirements for a specific area.

Sprinklers in areas without finished ceilings shall be quick response brass upright, glass bulb type
sprinklers rated for the ordinary temperature range unless specifically noted otherwise on the fire protection
drawings or needing to be a higher range to comply with NFPA 13 requirements for a specific area.
UL Listed sprinkler guards shall be provided where required by this contract or NFPA requirements to
prevent mechanical damage.
Spare sprinklers and a storage cabinet shall be provided in accordance with NFPA 13.

2.06 WATERFLOW PADDLE SWITCHES
A waterflow paddle switch shall be furnished for each sprinkler zone and sub-zone to indicate system
actuation. The switch shall be designed to withstand at least 250 psi (17.2 bar).
Waterflow switches shall have two sets of single-pole, double-throw (SPDT), contacts. Waterflow switches
for the general sprinkler zones shall have an adjustable retard feature. The waterflow switch for the elevator
hoistway shall not have the capability of time delay. Terminals shall be provided for external wiring
connections. The switches shall be watertight.

2.07 VALVE TAMPER SWITCHES
Valve tamper switches shall be “Potter Model OSYSU” or acceptable equal and shall be watertight. A
minimum of two (2) sets of SPDT (Form C) contacts shall be provided. Terminals shall be provided for
external wiring connections. Each switch shall be arranged to cause a supervisory alarm if the housing
cover is removed, or if the unit is removed from its mounting. Integral tamper switches are required for
butterfly valves.
PART 3 – EXECUTION

This section covers the installation and installation material requirements for the sprinkler system.

3.01 GENERAL

3.01.1 Products and Materials

Unless specifically provided otherwise in each case, all products and materials furnished for permanent installation in the work shall conform to the applicable standard specifications and shall be new, unused, and undamaged.

All products and materials furnished for incorporation into the work shall be asbestos free.

3.01.2 Personnel

As noted in Part 1, the Installation Supervisor shall be on the job site during the entire installation. The supervisor shall have all contract documents on site at all times. The supervisor shall also have a copy of all submittals (shop drawings and all other documentation). The supervisor shall be responsible for daily updating of the shop drawings and other data to reflect the actual installation (red-lines). These drawings shall be made available to the Owner and/or Engineer for review at any time.

The Contractor’s personnel shall abide by all security and safety requirements of the Owner.

3.01.3 Workmanship

Details of erection work not covered herein shall conform to accepted good engineering practice, the Contract drawings, applicable nationally recognized codes, and all applicable state and local codes.

All defects in erection shall be corrected to the satisfaction of the Owner. The dismantling and reassembly of equipment to remove defective parts, replace parts, or make adjustments shall be included as a part of the work under these specifications.

3.01.4 Working Hours

Working hours shall be coordinated with the General Contractor.

3.01.5 Construction Phasing

Construction phasing shall be coordinated with the General Contractor and be acceptable to the Owner.

3.01.6 Impairment of Existing Fire Protection Equipment

The Contractor shall arrange all installation schedules to minimize fire protection system impairment time and minimize disruption to the Owner. Specific requirements are as follows:

1. Notice of the impairment of the sprinkler system or standpipe system shall be submitted to the Owner in writing for approval, at least 48 hours in advance. The system shall be back in service at the end of each day if requiring more than one day unless specific written
authorization is provided by the Owner.

3.02  **PIPING**

3.02.1 The Contractor shall design, detail furnish, fabricate, and erect all piping required for the fire suppression systems included under these specifications and all other piping required for complete and functional piping systems. Requirements for design, detailing, fabrication, and erection of piping are included in the following articles.

3.02.2 Pipe supports shall be provided for all piping included under these specifications, as defined in the article herein entitled Piping Supports.

3.02.3 **Piping Arrangement**

3.02.3.1 The Contractor’s piping arrangement shall take into consideration, and provide for such adjustment as may be required to avoid interference with the Owner's piping and equipment. The piping shall be arranged such that a clear access is provided to all equipment or devices that require maintenance. Piping that does not meet the above requirements will be relocated at the Contractor’s expense. The sprinkler piping shall be routed as close to the structural deck as possible.

3.02.3.2 All piping shall be installed in such a manner as to present an orderly and neat installation. Valves, instruments, and other special items shall be placed in locations convenient for operation by the operating personnel. Piping runs shall be plumb or level, except where pitch for drainage is required. All piping shall be installed perpendicular or parallel to the building structure, and floor levels except in special cases consented to in writing by the Owner or Engineer.

3.02.3.3 All piping, including tubing, shall be installed in accordance with the following additional requirements:

3.02.3.3.1 **Piping**

Piping shall not be installed above, or within a horizontal distance of 3 feet (914 mm) from, electrical equipment such as switchgear, switchboards, control panels, motor controls, contactors, communication equipment, unless written consent of the Owner is obtained. Improperly located piping shall be removed and relocated at the Contractor's expense. Piping in areas with finished ceilings, shall be routed above the ceilings and shall not interfere with ceiling tile removal. Piping in areas without finished ceilings, and under ductwork, etc. shall be installed with a minimum of 7'-6" (2,286 mm) headroom over passageways and walkways. Clearance less than 7'-6" (2,286 mm) shall require the written acceptance of the Owner. Piping shall not interfere with day-to-day operation or maintenance of any building equipment.

3.02.3.3.2 **Drains**

The Contractor’s piping shall be arranged with adequate slope, and with valved drains, so as to be completely drainable.

Sprinkler system main drains and trim drains shall terminate not over 12
inches (305 mm) above a Contractor provided concrete splash block outside the building. Piping shall be turned down with a 45° elbow. Wall penetrations shall be sealed.

All low points shall be provided with drains and valves. Drains shall be coordinated with the plumbing Contractor to terminate at floor drains. The Contractor shall provide signs for all drains in accordance with NFPA 13.

A ball drip assembly shall be provided in the low point(s) of the Fire Department Connection piping.

3.02.4 Piping, Fittings, and Materials

Materials and connection types for pipe and fittings shall be as described below.

3.02.4.1 Piping

Fire protection water supply piping within the building up to the system isolation valves shall be black steel, Schedule 10 minimum.

Sprinkler piping downstream of the isolation valves, 2½ inches (65 mm) and larger shall be black steel, Schedule 10 minimum. Piping under 2½ inches (65 mm) shall be Schedule 40 minimum.

All piping shall also meet the requirements of NFPA 13. Schedule 10 piping shall be FM Approved for its intended use.

Threading of piping with a wall thickness less than that of Schedule 40 is prohibited.

As prescribed by NFPA 13, 2010 Edition, Section 6.5.1.1, all threaded fittings and pipe shall conform to ANSI Standard B1.20.1, Pipe Threads. The Contractor shall have a full set of taper threaded ring and plug gauges referenced by ANSI B1.20.1 and shall check every fifteenth thread cut in the fabrication shop. Threads found out of tolerance shall be rejected, and the tool dies shall be adjusted or replaced until within tolerances. Field threading shall be performed only if absolutely necessary. Standard threaded fittings purchased from an approved manufacturer and not cut by the Contractor or fabricator need not be checked by the Contractor.

The external surface of all exposed piping, and all exposed components of shop fabricated piping supports shall be clean to allow priming and painting by others.

3.02.4.2 Fittings

Except as otherwise specified herein, fittings such as tees, couplings, crosses, elbows, caps, and reducers shall be used for all changes in direction, intersections, size changes, and end closures of piping.

Threaded, flanged, or mechanical fittings shall be cast or malleable iron, Class 125 minimum. Threaded fittings are not permitted on pipe with wall thicknesses less than Schedule 40.

Bushings shall not be used in place of standard fittings. If fittings are approved with a
specific pipe manufacturer or grooving process, that pipe or grooving process shall be provided.

Plain end fittings (non-grooved) are prohibited.

FM Approved Flexible Sprinkler Hose is permitted, if specifically approved by the AHJ.

3.02.4.3 Thread Sealant

Pipe thread sealant shall be Teflon ribbon or approved joint compound.

3.02.4.4 Cleaning

The inside and outside of all pipe, valves, and fittings shall be free from dirt, sand, and loose mill scale before being erected. Before placing in service, all lines shall be thoroughly blown and/or flushed.

3.02.5 Piping Supports

The Contractor shall furnish and install all required supports for all piping erected under these specifications. The term “piping supports” includes all assemblies such as hangers, floorstands, anchors, brackets, bracing, and any supplementary steel required to attach piping supports. NFPA 13 minimum pipe supports are acceptable only when also in compliance with these specifications. Piping support systems shall be FM Approved.

The Contractor shall be responsible for location and design of all supports for all piping required under these specifications.

All piping support spacing shall be designed in accordance with the requirements of NFPA 13.

3.02.5.1 Contractor’s Drawings

Standard details shall be prepared for all piping support assemblies furnished under these specifications. Details for each system shall be illustrated on the Contractor’s shop drawings or provided in the product submittals.

The details shall show method of attachment to the structure or slab; all components including rods, turn buckles, rod couplings, eye nuts, hanger; and pipe size range. Each component of the assembly shall be identified as to manufacturer and model number. Manufacturer's data sheets shall be provided for all components chosen.

Specific assembly sketches shall be provided for non-typical pipe supports or supports that require addition of supplementary steel. If all components are not specifically Approved, design data and calculations are required to prove compliance with NFPA 13 requirements.

3.02.5.2 Code Requirements

All piping support design, construction, materials, and installation shall be in accordance with the provisions of NFPA 13, "Sprinkler Systems," unless otherwise specified herein; and in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards."
3.02.5.3 **Design and Layout Requirements**

All supporting component layout shall be checked by the Contractor for interference and obstructions with equipment and other building components.

Any supplementary structural steel members required for support attachment shall be furnished by the Contractor. Any reinforcing of building structure required for supports shall be furnished by the Contractor. Net supporting effect at operating condition shall not induce forces or moments on the piping system terminals. Under conditions other than operating, supporting effect shall not induce excessive forces or moments on the piping, equipment, or supports.

3.02.5.3.1 **Appearance**

Piping supports shall be constructed and installed to provide an orderly and attractive appearance. Adjacent supports shall be of the same type and component assembly insofar as practicable. Corresponding parts of adjacent hangers shall be set at the same elevation. The use of trapeze type supports shall be avoided unless accepted by the Engineer. Two or more supports attached to the same part of the building structure shall be in line, rather than staggered.

3.02.5.3.2 **Materials**

Material requirements for support components shall be as specified herein.

Support components shall be carbon steel material of an ASTM type having a minimum yield strength of 35,000 psi (2,413 bar) and a minimum ultimate strength of 58,000 psi (3,999 bar).

Malleable iron hanger materials shall not be used.

Supplementary support beams required for attaching supports to the building structure shall conform to ASTM A36.

Pipestand support materials shall be sized to meet or exceed the minimum requirements as follows:

<table>
<thead>
<tr>
<th>Pipe Size, Inches (mm)</th>
<th>Floorstands, Minimum Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2½ (65 mm)</td>
<td>1½ (40 mm)</td>
</tr>
<tr>
<td>3 (80 mm)</td>
<td>2 (50 mm)</td>
</tr>
<tr>
<td>4 (100 mm)</td>
<td>2½ (65 mm)</td>
</tr>
<tr>
<td>6 (150 mm)</td>
<td>3 (75 mm)</td>
</tr>
<tr>
<td>8 (200 mm)</td>
<td>3 (75 mm)</td>
</tr>
</tbody>
</table>

3.02.5.3.3 **Structure Attachments**

Structure attachment components shall be fastened by bolting. C-Type
Clamps are acceptable only when installed with retaining straps.

The use of structural attachments that apply torsional loads to structural steel is to be avoided, if possible. If torsional loading cannot be avoided, specific design details and calculations shall be submitted to the Engineer for acceptance.

Attachments to concrete (cast-in-place only) ceiling or, concrete or masonry walls shall be used only when attachment to building steel or added supplementary steel is impractical. Anchor bolts furnished loose with the supports shall be the cone expansion type which conform with Federal Specification FF-S-325, Group II, Type 4, Class 1 and Factory Mutual (FM)Approved. Powder driven studs are not permitted. Expansion anchor design shall meet the following criteria:

3.02.5.3.3.1 Minimum safety factor of five.

3.02.5.3.3.2 Use of expansion anchors attached directly to hanger rods in concrete decks shall be limited to 3 inch (80 mm) and smaller diameter pipe. Pipe greater than 3 inches (80 mm) in diameter shall be attached using concrete attachment plates utilizing at least two (2) expansion anchors.

3.02.5.3.3.3 Expansion anchors used in masonry walls shall not exceed a ¾ inch (19 mm) nominal diameter.

3.02.5.3.3.4 Minimum edge and spacing distances in accordance with the manufacturer's recommendations.

3.02.5.3.3.5 Use in masonry shall be subject to review and acceptance of the plans by the Engineer.

3.02.5.3.3.6 Calculations prepared and stamped by a registered professional engineer shall be provided for any concrete attachment designs requiring non-approved components, to prove NFPA 13 compliance.

Special attention shall be given rigid floorstands, such as base elbows, so that excessive forces and stresses are not induced in piping, equipment, or building structure.

3.02.5.3.4 Supplementary Support Beams

Unless otherwise indicated, supplementary steel beams shall be attached to building steel by means of clip angles welded to the web of the building beams or columns. These clip angles shall conform to "Framed Beam Connections" as indicated in the latest AISC Manual of Steel Construction. Clip angles shall be securely attached to the supplementary beams by bolting for shipping and installation purposes. Bolting shall be through elongated holes in the beam web. Permanent attachment shall be by field welding.
3.02.5.3.5 Rods

Hanger rods shall be constructed of solid, round, steel bars not less than 3/8 inch (9.5mm) in diameter. Rod diameter shall match the rod holes in the hanger components and shall meet or exceed the hanger capacity.

Forged steel turnbuckles or rod couplings shall be provided in hanger assemblies unless the arrangement provides other means of vertical adjustment under load. Steel turnbuckles or rod couplings shall be used to couple long rods. Rod couplings shall be UL Listed or FM Approved for sprinkler piping. Turnbuckles, rod couplings and other threaded adjustment components shall be provided with locknuts.

3.02.5.4 Erection of Piping Supports

Hangers, supports, and anchors shall be installed as required to obtain a safe, reliable, and complete piping installation. All supports shall be properly leveled and anchored when installed.

Hanger assemblies shall not be used for the attachment of rigging to hoist the pipe into place. The piping shall be securely held in place by other means until the pipe support is completely assembled and attached to the pipe and structures. All rigging shall be removed in such a manner as to not impose a sudden load on the pipe support.

3.02.6 Cutting and Drilling of Structures

All necessary drilling, cutting, and patching of structures required for proper installation of piping or bolts shall be done, but only as specified herein, or with the written consent of the Owner.

Holes in concrete floors shall be provided with machine cut steel pipe sleeves in accordance with the details indicated on the contract drawings. All openings in concrete shall be made by core drilling, saws, or similar clean cutting equipment.

3.02.7 Firestopping

The Contractor shall be responsible to provide penetration seals where pipe penetrates floors and fire rated barriers or walls or all floors requiring opening protection. See the Architectural drawings for locations and ratings of fire walls.

Fire rated barriers walls and walls in the area of sprinkler installation are as follows:

1. Stairwell, Mechanical and Elevator Shafts

Firestopping will have a rating equivalent to the rating of the wall or floor being penetrated (two hours unless noted otherwise). Firestopping materials and methods shall be in accordance with a specific Underwriters Laboratories Listed System for the materials being penetrated.

3.03 PIPE WELDING

All shop welding shall be in accordance with the ASME Code for Pressure Piping, ANSI/ASME B31.1, Power Piping. Field welding is prohibited.

3.04 EQUIPMENT LOCATIONS AND DETAILS OF INSTALLATION
All equipment shall be located in accordance with NFPA and other referenced code requirements. Additional requirements are as follows:

3.04.1 Sprinkler System Valves and System Isolation Valves

Sprinkler system isolation valves including test and drain stations shall be located at the valve station as shown on the drawings.

Sprinkler system valve height shall not exceed five feet (1,520 mm) and shall be oriented for easy access for maintenance.

Permanent system identification signs shall be provided on these isolation valves and all trim valves in accordance with these specifications and NFPA 13. Valve stations for dry pipe and preaction valves shall have a sign identifying the number and locations of all low point drains.

3.04.2 Sectional and Isolation Valves

Isolation valve height shall not exceed seven feet unless specifically noted otherwise in the contract documents. Stems shall be oriented to allow easy use; however, not be an obstruction to normal building operations. Exact valve locations are subject to the approval of the Engineer. The Contractor shall provide signs in accordance with NFPA 13. The signs shall include verbiage for normally open or normally closed.

3.04.3 Valve Tamper Switches

Switches shall be mounted so as not to interfere with normal operation of the valve and adjusted to operate within two revolutions toward the closed position or no more than one-fifth of the distance from its normal position. The minimum groove depth and width in valve stems shall be in accordance with the manufacturer’s guidelines.

3.04.4 Sprinklers

Sprinklers installed less than eight feet (2,440 mm) above the walking surface shall be provided with UL Listed guards to prevent mechanical damage. See Paragraph 1.10 for additional areas requiring guards.

3.04.5 Spare Sprinkler Cabinet

The spare sprinkler cabinet shall be located where directed by the Owner.

3.05 TEMPORARY PIPING AND EQUIPMENT

All equipment, piping, valves, and fittings temporarily required in the course of erection, cleaning, and start-up shall be furnished and installed. This shall include blanking fixtures required to seal off piping terminals for hydrostatic tests. When no longer required, all temporary materials shall be dismantled and shall remain the property of the Contractor.

3.06 DEMOLITION

Wall and floor openings created by the Contractor shall be sealed with materials matching the existing element’s construction. Repair methods and materials shall maintain any existing element’s fire rating and
are subject to the Engineer’s approval.

3.07 TRAINING

Training shall be provided for the operations and maintenance staff. Training shall be conducted in the building where the system is installed or as designated by the Owner. The training period shall be a minimum of one 4-hour session and shall start after the system is functionally completed but prior to final acceptance tests. The instructions shall cover all of the items contained in the operating and maintenance instructions.

3.08 SYSTEM TESTS

3.08.1 General

This sub-section covers testing of the fire protection system furnished, and installed under these specifications. All defects discovered by testing shall be corrected and the systems retested.

3.08.2 Pre-Tests

The Contractor shall notify the Owner and Engineer in writing of the proposed pre-test date at least two weeks in advance. Test date and time are subject to the approval of the Engineer. The Owner may witness the pre-test.

The Contractor shall completely pre-test the systems after installation is complete and prior to the final acceptance test. The Contractor shall provide the Owner and the Engineer with a "Contractor's Material and Test Certificate" for the fire protection systems installed herein, in accordance with NFPA 13 at least 48 hours before the final acceptance test.

3.08.3 Final Tests

The Contractor shall notify the Engineer in writing of the proposed test date at least two (2) weeks in advance. Test date and time are subject to the approval of the Engineer. The Engineer will witness all final acceptance testing.

3.08.4 Test Requirements

The following are the minimum tests to be performed for each type of system. All labor and equipment for testing shall be provided by the Contractor. Calibrated gauges shall be used for all testing. Pre-testing shall include all items listed below. Final testing will include all items except hydrostatic testing.

3.08.4.1 Wet Pipe Automatic Sprinkler System Testing

The following tests shall be performed for the wet pipe sprinkler system and feed main from the Phase 3A valve station:

3.08.4.1.1 Hydrostatic Test

The system shall be hydrostatically tested at not less than 200 psi (13.8 bar) for a minimum of two hours in accordance with NFPA 13. The test pressure shall be read from a gauge located at the lowest point of the system. There shall be no visible leakage during the test.
3.08.4.1.2 System Flow Test

The inspector’s test shall be opened. The alarm shall be verified at the local Fire Alarm Panel.

3.08.4.1.3 Valve Tamper Switch Test

The valve shall be closed two turns or one-fifth of the travel distance to activate the valve tamper switch. The supervisory signal shall be verified at the local Fire Alarm Panel.

3.08.4.1.4 Main Drain Test

The Contractor shall perform a main drain test in accordance with NFPA 25 and record the results on the Contractor’s Material and Test Certificate.

The Owner or Engineer may terminate the acceptance test at any time based on an unacceptable number or magnitude of deficiencies.

If the system fails the final test, the Contractor shall be responsible for the costs for the Owner and the Engineer for additional testing.

Final acceptance of the alarm system shall be based on satisfactory completion of all items listed above and trouble-free operation for a period of 30 days after completion of the test.

END OF SECTION 211300
SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide items, articles, materials, operation and methods required by drawings and specifications including labor, equipment, supplies and incidentals necessary for completion of work in Division 22 – Plumbing.


C. Furnish and install as shown on the drawings and as specified herein.

1. Sanitary Drainage System consisting of all piping, floor drains, hub outlets, plumbing fixtures and trim, cleanouts, vents, etc..

2. Domestic Cold-Water Supply System consisting of all piping, backflow preventers, pressure reducing valves, flow meters, valves, insulation, hose bibbs, thermal expansion absorber, etc., and connect as shown on the drawings and as required. Extend to all plumbing fixtures, and equipment requiring water.

   1. Waste Systems
      a. Clearwater waste systems consisting of all piping, including HVAC condensate and ice machine discharge, complete with cleanouts, hub outlets, traps, etc., and connecting to systems as shown on drawing, per approval of local administration. Discharge must exclude sanitary flow.
      b. Relief Valves Discharge piping to direct discharge from relief valves to a drain or location in which scalding hot water is unlikely to strike people and discharge without property damage due to flooding.

2. Storm Drainage Systems
   a. Drainage systems work shall consist of coordination of locating all aboveground and underground piping, drains and pipes passing through walls and roofs.
   b. Roof drainage, consisting of locating, setting and flashing roof and overflow drains sumps, installation and connecting of roof drains, overflow drains, horizontal conductors, vertical downspout and leaders, cleanouts, and coordinate installation with roofing contractors.
   c. Overflow drains shall be piped separately from the primary system to a separate disposal point so that blockage of the primary drainage will not affect the effective of the overflow drainage system. Means for disposal of the overflow drain discharge must meet the requirements of the local codes. Open discharge on the street may not be allowed, especially in northern climates.
   d. Site drainage, consisting of location and installation of area drains, footing drainage, sump drains and pumps, inlets, catch basins, manholes and cleanouts.

3. Building Drains
Floor Drains - Furnish and install all work incidental to the foregoing items to be performed under this contract, such as:

b. All plugged tee and valved outlets
c. All cutting and patching of work of any nature unless otherwise specified herein
d. All pipe and equipment hangers, platforms, support bases, anchors, guides, expansion loops, vibration eliminators, etc., unless otherwise specified herein
e. All required final connections to equipment

D. All cleaning, disinfecting and testing

1.2 RELATED DOCUMENTS

A. The General Provisions described herein, together with the conditions of contract, and the General Requirements of Division 1, apply to the work in Division 22 – Plumbing.

B. This Section is hereby made a part of all other Sections of Division 22 – Plumbing, as if repeated in each.

1.3 QUALITY ASSURANCE

A. All permits and licenses that are required by governing authorities for the performance of shall be procured and paid for by the Contractor.

B. All work shall be performed in compliance with all applicable and governing safety regulations including the regulations of the Occupational and Safety Health Act. All safety lights, signs and guards required for performance of work shall be provided by the Contractor.

C. All work shall conform to the requirements of all applicable codes, ordinances and regulations including the rules and regulations of the National Electrical Code, the National Fire Protection Association, the International Plumbing Code, OSHA and all State and Local laws, codes and ordinances.

D. Laws, codes, ordinances and regulations shall take precedent excepting only where the work called for by the drawings and specifications exceeds by quality and quantity.

E. Fixtures, appliances, equipment and materials which are subject to Underwriter's Laboratory tests shall bear such approval.

F. Mechanical and electrical designs are based on the requirements for the specified manufacturers listed on the equipment schedules. Conduit, disconnects, motor starters, breakers, fuses and wire sizes are selected on basis of scheduled equipment. Increased current requirements necessitating larger wire, breakers, switches, etc., to accommodate any alternate or substitute manufacturer's equipment, other than as shown on drawings shall be provided without any increase in contract price by contractor furnishing the equipment.

G. Manufacturers, where specifically called for, must provide factory tests, unit installation observations, unit start-up and tests, etc., as specified, and submit signed reports to the Engineer upon completion of these services. Subletting of these services will not be permitted. Shop drawing submittals shall be accompanied with a letter of certification by
the manufacturer that the specified services shall be provided. Failure to do so shall be caused to reject the shop drawing submittals.

H. The contract drawings are in part schematic and intended to convey the scope of work and indicate the general layout, design and arrangement. The Contractor shall follow these drawings in the layout of his work and shall consult general construction drawings, electrical drawings and all other drawings for this project, and shall verify all existing site conditions to determine all conditions affecting the work shown or specified. The contract drawings are not to be scaled and the Contractor shall verify spaces in which the work is to be installed.

I. Follow drawings in laying out work, check drawings of other trades to verify spaces in which work will be installed, and maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, Engineer shall be notified before proceeding with installation.

J. Work in cooperation with one another to fit piping and work from other Divisions into the structure as job conditions may demand. All final decision as to right of way and run of pipe, ducts, etc. to be made by Engineer or his representative.

K. All work shall be performed by trained mechanics of a particular trade involved and done in neat and workmanlike manner as approved by "Engineer".

1. Work shall be performed in cooperation with other trades and scheduled to allow timely and efficient completion of project.
2. Furnish other trades advance information on locations and sizes of frames, boxes, sleeves and openings needed for work, and also furnish information and shop drawings necessary to permit other trades affected to install their work properly without delay.
3. Where there is evidence that work of one trade will interfere with work of other trades, all trades shall assist in working out space conditions to make satisfactory adjustments.

L. Work installed before coordinating with other trades causing interference with work of such other trades shall be changed to correct such condition without increase in contract price and as directed by Engineer.

M. Where specific details and dimensions are not shown on the drawings, the Contractor shall take measurements and make layouts for the proper installation of the work and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications, it shall be assumed, by the signing of the Contract, that the higher cost (if any difference in costs) is included in the contract price, and the Contractor shall perform the work in accordance with the drawings or with the specifications, as determined and approved by the Engineer.

N. The Contractor shall be responsible for a scheduled sequence in performing the work so that it will not interfere with the Owner's operation in the existing building. Before any work is started, the Contractor shall consult with the Engineer and Owner and arrange a satisfactory schedule.

1. Make temporary alterations as required to execute work so that all operations and services in the existing building are maintained with the minimum possible interruption.

COMMON WORK RESULTS FOR PLUMBING 220500- 3
2. Temporary shut-downs shall be segregated and shall be of the shortest possible duration. All facilities shall be kept in continuous operation unless specific permission to the contrary is granted by Owner.

O. Definitions:

1. "Piping" includes, in addition to pipe, all fittings, valves, sleeves, hangers, and other supports and accessories related to such piping.
2. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction, or in crawl spaces.
3. "Exposed" means not installed underground or "concealed" as defined above.
4. The words "furnish and install", "provide", "furnish", "install", or equivalent words are used or are understood, to mean the Contractor shall furnish and completely install the system, service, equipment, or material named, together with other associated devices, equipment, material, wiring, piping, etc. as required for a complete operating installation, and conforming to the manufacturer's standards and recommendations.
5. It is the intent of these specifications and drawings to call for finished work, tested and ready for operation.
6. All apparatus, appliances, materials or work not shown on drawings, but mentioned in specifications, or vice versa, and/or all incidental accessories necessary to make work complete and ready for operation, even though not specified or shown on drawings, shall be furnished and installed without increase in contract price.
7. Should there be discrepancies or questions of intent, refer matter to Engineer in writing for decision before ordering any equipment or materials or before starting any related work.

1.4 SHOP DRAWINGS AND SAMPLES

B. Shop drawings, project data and samples furnished by the Contractor shall illustrate materials, equipment or workmanship, and establish standards by which the work will be judged.

C. Shop Drawings and Samples shall be submitted to the Engineer by a letter of transmittal. The party making the submission shall be named on Shop Drawing/Sample and also in the letter of transmittal.

D. When Shop Drawing submissions are in the form of loose pages (8½" x 11") they shall be submitted in sets assembled in portfolio binders showing on the covers or first page inside, a complete list of contents. A minimum of 7 sets of each submission are required, however, additional copies may be requested.

E. When Shop Drawing submissions are in the form of portable document format (PDF), they shall be transmitted via email to the contact information provided during the pre-construction conference. Each submittal transmitted in PDF format shall include only one specification section. Multiple specification section submittals combined into one singular PDF file will not be accepted. The cover page of the submittal shall include all necessary information for proper identification of project, submittal, and date, and shall include a blank area, minimum 4-1/4" by 5-1/2" in size, for placement of the engineer’s review stamp. The email transmittal and PDF file naming shall be compliant with the following guidelines:
1. Email submittals to be addressed to: TBD, as instructed during pre-construction conference.

2. Email subject line shall include the following information, in order of listed below and separated by dashes:
   a. “SUBMITTAL”
   b. Project Number (as listed in titleblock and specifications).
   c. Specification Section Number
   d. Specification Title
   e. “FOR REVIEW”
   f. Example: “SUBMITTAL-16076.1-220523-Plumbing Valves-FOR REVIEW”

3. The PDF file for the actual submittal shall be compliant with the following guidelines:
   a. Project Number (as listed in titleblock and specifications).
   b. Specification Section Number
   c. Sequence Number (separated from section number by a ‘dot’). In the case of a resubmittal, the sequence number shall remain the same as the previously submitted file, and shall be
   d. Specification Title
   e. “FOR REVIEW”
   f. Example: “16076.1-220523.01-Plumbing Valves-FOR REVIEW.pdf”.

4. Failure to follow email transmittal or document naming guidelines will result in an automatic rejection of submittal.

F. The Contractor shall review, stamp with his approval and submit, with reasonable promptness and in orderly sequence so as to cause no delay in the work or in the work of any other contractor, all Shop Drawings and Samples required by the Contract Documents or subsequently by the Engineer as modifications. Shop Drawings and Samples shall be properly identified as specified or as the Architect/Engineer may require. At the time of submission, The Contractor shall inform the Architect/Engineer in writing of any deviation in the Shop Drawings or Samples from the requirements of the Contract Documents.

G. Except in the case of brochures, catalogue cuts and the like, shop drawings shall be in the form of a reproducible print(s) (sepia). In every case, the submittal shall consist of one sepia of each shop drawing and two (2) black line prints of the same. Each print shall be made from the original shop drawing tracing. The transparency shall be capable of producing clean, clear black and white prints.

H. Contractor shall stamp each sepia and black line print (shop drawing) the same. He shall also stamp each brochure, sample and the like. Special Note: Every page with project information shall be stamped. In every instance, the document shall be reviewed by the Contractor and shall also be signed by the Contractor indicating that the document has been reviewed, and that it is approved by the Contractor. The submittals will not be reviewed without the Contractor’s approval stamp and signature.

I. The Contractor’s approval stamp and signature shall signify that the Contractor has checked the submittals. Any submittals which have not been checked shall be returned to the Contractor for checking, approval stamp, signature, and resubmittal for compliance with the contract documents. After review of the submittals they will be returned to the Contractor with one of the following remarks checked:
1. No Exceptions Taken SUBJECT TO CONTRACT DOCUMENTS.

2. Note Corrections SUBJECT TO CONTRACT DOCUMENTS RESUBMISSION
   NOT REQUIRED.

3. Revise and Resubmit REVISE, RESUBMISSION REQUIRED.

4. Rejected NOT APPROVED.

J. Upon receipt of exhibits submitted and marked for resubmittal the Contractor shall cause the marked corrections and corrections that may be contained in the Architect/Engineer transmittal letter to be made on each submittal. All such corrections shall be circled, numbered, and dated to permit prompt reviewing upon resubmittal to the Architect/Engineer. Upon receipt of each submittal now marked:

K. The Contractor shall cause submittals to be distributed to the respective contractors and suppliers as is necessary for proper performance of work.

L. At the time of submission, the Contractor shall inform the Engineer in writing of any deviation in the exhibits submitted from the requirements of the Contract.

M. The Engineer will review exhibits submitted with reasonable promptness so as to cause no delay, but only for conformance with the design concept of the Project and with the information given in the Contract. The Engineer's review of a separate item shall not indicate review of an assembly in which the item functions. The Engineer's review is not intended to indicate approval of dimensions or quantities.

N. Contractor shall make any corrections required by the Engineer and shall resubmit the required number of submittals until further resubmittals are no longer required.

O. Engineer’s review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract unless the Contractor has the Engineer's approval in writing of such deviation at the time of submission and the Owner's Representative has given written notice to the specific deviation; nor shall the Engineer's review relieve the Contractor from responsibility for errors or omissions in the submitted exhibits.

P. No portion of the work requiring a submittal shall be commenced until the Engineer has reviewed the submission. All such portions of the work shall be in accordance with reviewed submittals.

1.2 OPERATION AND MAINTENANCE MANUALS

A. In addition to the requirements specified in Division 1, the Contractor at the project’s completion shall submit a complete system operating and maintenance manual. O&M manual shall be organized into systems and shall contain the manufacturer's complete detailed operating and maintenance instructions with equipment data for each piece of installed equipment furnished under this project. Manual at a minimum shall include the following:

B. Manual shall be composed of typed instructions sheets with large drawing sheets (not reduced) folded in with reinforced margin, shall have a post binder system so that sheets can be easily substituted, and shall have a hard cover.
C. Include in O&M manuals Manufacturers written maintenance instruction for each different piece of equipment provided and installed on this project.

D. Include spare parts list for each major piece of equipment furnished for the project including but not limited to medical gas zone panels, control panels, and accessories.

E. Provide a comprehensive list of maintenance procedures for preventative maintenance and troubleshooting; disassembly, repair and reassemble; aligning and adjusting instructions.

1.3 REGULATORY REQUIREMENTS

A. The entire plumbing installation shall comply fully with requirements of all applicable State and local laws, codes and ordinances.

B. The work shall also comply with all applicable requirements of the National Fire Protection Association (NFPA), Occupational Safety and Health Act (OSHA), the 2012 International Plumbing Code (IPC), Providing Accessibility and Usage For The Physically Handicapped People (ANSI A117.1) and the Environmental Protection Agency (EPA).

C. A reference to an ANSI or ASTM Standard shall indicate that the article shall conform to that standard in all respects (including material, manufacture, handling, dimensions, and test procedure).

1.4 JOB CONDITIONS

A. Inspect existing site conditions affecting the work before submitting bid.

B. Take all measurements for plumbing work and shop drawings with all other contractors affected and make any necessary offsets required to conceal piping and to clear equipment, structural members and other obstructions.

C. Protect all work, materials, fixtures and equipment from damage. Cap or plug temporary openings. Deliver all work to the owner clean and in perfect condition. Keep work areas clear of debris. Promptly remove waste material from the premises.

1.5 CLEANING AND DISINFECTING

A. Piping systems shall be cleaned and disinfected as hereinafter specified. All equipment, temporary piping, chemicals, etc., as required shall be furnished by the Contractor.

1. Domestic Water Systems: All system piping and equipment shall be thoroughly and completely flushed with cold city water. Completely drain the systems and fill with a solution of Sodium or Calcium Hypochlorite, 100 parts per million, completely relieve the system of all air. Allow the solution to stand for eight (8) hours and then drain and follow with a clear water flush for a sufficient period of time to remove all traces of hypochlorite odor. Disinfecting chemicals shall not be introduced into existing piping systems.

B. Immediately prior to final inspection the Contractor shall make a final cleanup of dirt and refuse resulting from his work and shall make the premises broom clean. The Contractor shall clean all material and equipment installed under the contract. Damaged finishes shall be touched-up and restored to their original condition.
1.6 PIPING TESTS

A. All piping shall be tested, leaks repaired, and systems retested until proven tight before backfilling, concealing or insulating pipe.

1. Test drainage and vent systems with water or air in accordance with requirements of the International Plumbing Code and all applicable local Codes. Water test may be applied to entire drainage systems or sections of systems. All openings shall be tightly closed in section to be tested except at highest opening. All portions of systems shall be subjected to a minimum of 10 feet head of water. Water must have been in the system 15 minutes prior to inspection. Air test in accordance with the Uniform Plumbing Code may be used at Contractor’s option.

2. Hydrostatically test entire domestic water system to 100 psig or higher pressure as required by local Code.

3. Work shall include all testing equipment.

PART 2 - EQUIPMENT

1.7 GENERAL

A. All materials and equipment shall be new and shall bear manufacturer’s name, model number and other identification marking.

B. All materials and equipment shall be standard product of manufacturer regularly engaged in production of required type of material or equipment for at least 5 years (unless specifically exempted by Engineer) and shall be manufacturer’s latest design having published properties.

1.8 EQUIPMENT FURNISHED BY OWNER OR OTHER TRADES

A. Owner furnished equipment includes the following:

1. As specifically noted on drawings.

B. Equipment furnished by other trades includes the following:

1. As specifically noted on drawings.

C. General

1. The following paragraphs describe the Contractor’s responsibilities for receiving and installing this equipment after shipment from the Manufacturer. Contractor shall complete all installation in accordance with this and other relevant Sections within this Division.

D. Receiving and Inspection

1. All equipment is shipped F.O.B to the jobsite. All delivery and transportation charges will be prepaid, so that Contractor will not incur additional shipping charges. Upon receipt of equipment, Contractor shall inform Owner/Owner’s Representative and provide a copy of the bill of lading. Maintain delivery records for inventory control and for use in processing payment request vouchers.
Crosscheck delivery records with project schedule so as to eliminate work stoppages due to material shortages.

2. The Contractor shall be responsible for coordinating with the manufacturer for installation of the equipment furnished above as shown on drawings. The Contractor shall be responsible for warranty work required and shall coordinate with the manufacturer of the equipment to accomplish warranty work including any labor and additional cost for such warranty work. The Equipment Manufacturer shall provide the Contractor with installation manuals and instructions to the Contractor. The Contractor shall receive and install this equipment for a complete furnished and installed installation including all accessories as specified within these specifications and as shown on drawings.

3. The Contractor shall check equipment and trim delivered to job site by Equipment Supplier against approved shop drawings or other required documentation. The Contractor shall report all discrepancies, shortages, or lack of data to the Owner and Equipment Supplier for adjustments within 1 week after equipment is received. If such report is not made within one week, it shall be assumed no discrepancies, shortages, or lack of data has been found.

4. The Contractor is responsible for off-loading of shipped equipment. Contractor shall handle products, materials, and equipment in accordance with manufacturer's recommendations and recognized industry standards. Contractor shall utilize lifting lugs, and designated lift points when hoisting equipment. In all cases, Contractor shall carefully handle, transport, and position items to prevent damage during construction.

5. An access restricted area shall be provided for the storage of all supplemental equipment, accessories and materials. This restricted area shall be divided into two distinct areas designated as “quarantined” and “released”. The storage area designated as “quarantined” shall be used to store equipment, materials and accessories prior to inspection and acceptance. Under no circumstances shall an item be removed from quarantined storage until it designated as “released”. After the equipment, material or accessory has been inspected and approved for installation, based on the review of specifications and drawings, the item shall be relocated to the “released” area, where the contractor shall install the unit according to the project schedule.

6. Contractor shall store equipment and components in a manner to prevent damage and degradation. Store items on skids or pallets, elevated above the floor or grade. Store items subject to moisture damage in a dry location. Retain protective shipping covers, crates, and cartons during storage. Protect items from contamination by jobsite dirt and debris and other foreign matter. Provide a secure, fenced and lighted area for outside jobsite storage where required.

7. The Contractor is responsible for inspection and verification of all supplemental equipment. Contractor shall verify all equipment received is properly marked with product names, model numbers, types, grades, compliance labels, and other information needed for identification.

8. Shipment shall be verified in accordance with all data and information on specifications and submittals, including quantities, accessories, sizes, dimensions, utility requirements and general compliance. Contractor is responsible for final dimensions, verification of installation requirements and utility connections, which shall be confirmed at the job site. Contractor shall notify the Owner/Owner’s Representative of any deviations from the requirements of the Purchase Order, Drawings, or Specifications.

9. Contractor shall receive and inspect all tanks and agitators. Shipment shall be verified with approved shop drawings, and all attachments shall be accounted for.
If any accessory is not received contractor shall notify manufacturer. Contractor is responsible for tracking receipt and storage of all tanks and appurtenances.

10. If, during the course of inspection or installation, any of the goods received are found to be defective in material or workmanship, or otherwise not in conformity with the Purchase Order requirements, the Contractor shall notify the Owner/Owner’s Representative, who shall retain the right to reject or revoke acceptance and return the goods. Such goods are not to be repaired, altered or replaced without written authorization from the Owner/Owner’s Representative.

E. Installation

1. Contractor shall verify and integrate the installation of the supplemental equipment with the various elements of the building systems based on their review of latest information provided in the approved submittal data and coordination drawings. Install supplemental equipment to conform with all utility systems, electrical components and controls based on the Construction Drawings and the associated specifications provided. Where coordination requirements conflict with individual system requirements refer conflict to the Owner/Owner’s Representative.

2. If greater capacity or more materials or labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then it shall be the responsibility of the parties involved in providing the substitute and/or equivalent items of equipment to provide all compensation for additional charges made for the proper rough-in, circuitry and connections for the equipment furnished.

3. Contractor shall install supplemental equipment where indicated in the Construction Drawing set, in accordance with equipment manufacturer’s written instructions and with recognized industry practices, to ensure that the equipment complies with requirements and serves intended purposes. Contractor shall install supplemental equipment in accordance with manufacturer’s installation instructions, level and plumb, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.

4. Contractor shall connect and install all appurtenances, accessories and devices furnished by manufacturer but not specified to be factory-mounted or packaged separately for protection during shipping. For example, remote automated valves, utility booster pumps or tank agitators shall be installed per manufacturer’s recommendations as indicated on the drawings.

5. After placement or installation, cover items with tarps or sheeting where required to protect from damage during construction.

6. Contractor shall install tanks level and plumb. Installation of weigh cells, if required, under tanks shall be completed where indicated on drawings. Installation of tanks through floors, if required, shall be completed as indicated on drawings. Contractor shall install all appurtenances not installed at manufacturer’s facility.

7. After installation is approved, all agitators shall be bumped to check rotation.

F. Start-up and Commissioning

1. Prior to final acceptance, operate systems and equipment for a minimum of 48 continuous hours after normal operating conditions are achieved, as approved by the Owner/Owner’s Representative. The Contractor shall obtain suitable training or assistance for the operation of unfamiliar systems or equipment prior to start-up or operation. The Contractor shall clean systems or equipment and install new filters, screens, etc. based on manufacturer’s recommendations prior to final acceptance by the Owner/Owner’s Representative.
2. Adjust all systems and equipment to provide operation as described on the drawings and specified herein. Properly align and adjust drive components, bearings, etc. for all equipment to eliminate excess noise and vibration as acceptable to the Owner/Owner’s Representative.

3. Commissioning is the process of verifying that the installation of equipment has been completed in a manner that allows safe and acceptable start-up, and that the equipment is functioning as intended. Commissioning encompasses the testing and documentation required to be completed before the Contractor is finished. It will serve as a tool to alleviate post-occupancy difficulty or failure of supplemental equipment and shall record data in an effort to advance the systems from a state of substantial completion to dynamic operation and assist in the validation documentation. The Owner/Owner’s Representative and any issuance of completion certification shall complete the commissioning documentation prior to equipment installation acceptance. The documentation shall consist of Owner/Owner’s Representative provided checklists to be completed by the appropriate Contractor and verified by the Owner or Owner’s Representative. In many instances, the equipment Manufacturer will assist with commissioning services after installation. However, it is the responsibility of the Contractor to complete all documentation.

4. Commissioning activities shall be guided by protocols and datasheets furnished by Owner/Owner’s Representative, and will consist of installation verification, operational verification and documentation. An example of the commissioning documentation has been provided with the construction specifications. The Contractors responsibilities for installation verification will consist of an installation audit that will include information pertaining to material verification, manufacturer and model number, utility connections and flow data, loop checks, cleaning and passivation. The Contractor’s responsibilities for operational verification will consist of an operational audit that will consist of information pertaining to calibration, input/output testing, operating and control demonstration, alarm verification, and start-up.

1.9 **FIRESTOPPING**

A. Firestopping is defined herein as the process of furnishing and installing a material, or combination of materials, in various constructions to maintain an effective barrier against the spread of flame, smoke, and gases and to retain the integrity of time-rated construction. It shall be used in specific locations as specified hereinafter.

1. Piping penetrations through floor slab and through time-rated partitions of fire walls;
2. Opening between floor slabs and curtain walls, including inside hollow curtain walls at the floor slab;
3. Penetrations of vertical service shafts;
4. Openings and penetrations in enclosures with time-rated fire doors;
5. Other locations where specifically shown on drawings or where specified in other sections of these specifications;
6. Openings in non-time-rated construction shall be closed with a compacted fill of ¾ lb. density fiberglass and then sealed gas tight.

B. Material of firestopping shall be asbestos free and capable of maintaining an effective barrier against flame, smoke and gases in compliance with the requirements of ASTM E 814, UL NO. 1479. Fire-stopping material shall be manufactured by 3M barrier products. Products shall be capable of providing a cold smoke and water seal. When exposed to
temperatures exceeding 250°F these products shall rapidly expand up to ten times the original volume.

C. Installation of fire stopping shall be in accordance with the manufacturer’s recommendations and requirements. Surface to be in contact with firestopping shall be cleaned of dirt, grease, oil, loose materials, rust, or other substance that may affect proper fitting or the required fire resistance.

D. Firestopping materials shall provide an effective barrier regardless of the geometric configurations of the void spaces. Firestopping materials for filling voids in floors having openings of four (4) inches or more shall be installed to support the same load as the floor is designed to support, unless the area is protected by a permanent barrier preventing loading or traffic on the fire-stopped area.

E. At a minimum fire stop systems shall be designed to achieve a 2-hour F rating with an emphasis on also achieving a 2-hour T rating. In addition to fire and thermal protection, fire stop systems shall be designed to provide a barrier to the transmission of smoke and toxic fumes.

F. A firestop system as defined by these specifications shall consist of fire barrier products, in certain configuration and quantity, to meet the intent of the specifications above. Fire protection products include:

1. 3M fire barrier CS-195 composite sheet
2. 3M fire barrier moldable putty
3. 3M fire barrier CP 25WB caulk
4. 3M fire barrier FS-195 wrap/strip

G. Firestop systems for floor and chase penetrations shall be installed on both sides of the penetration (top and bottom) (in and out). Firestop systems shall be symmetrically installed on both sides and shall meet or exceed all requirements for AT&T standard practices.

1.10 ELECTRICAL EQUIPMENT

A. General: Unless specifically specified or shown otherwise, the Contractor shall furnish required motors, variable speed drives with controls, and disconnect switches for equipment furnished under this Division. Motors, drives, and associated controls, and disconnecting equipment shall be provided where indicated and as required for operation of the equipment being furnished. Motors shall be designed for full voltage starting unless otherwise specified or noted on drawings and shall be suitable for continuous duty at 40 C. ambient. All motors shall be selected, designed and fabricated in conformance with the requirements of NEMA-MG-1 standard.

B. All motors shall be NEMA Design B induction motors with voltage and phase scheduled on drawings. Motors shall be equipped with Class F insulation, rated with a service factor of 1.15 and nominal full-load efficiency within 1.5% of the maximum values provided by the National Electrical Manufacturers Association Standard 12.6C in publication MG 1. The motor efficiency testing standards for all motors is IEEE Standard 112-1984, “Standard Test Procedure for Polyphase Induction Motors and Generators”. All motors shall have a 2% - 5% power factor improvement over typical standard efficient motors. Motors shall comply with the frame size assignments of NEMA MG 13-1984. Motor nameplate horsepower ratings shall not be exceeded when the equipment is operating within the limits of the design
conditions specified. The motor loading shall not exceed the motor service factor rating on start-up conditions or at the equipment maximum load point.

C. Rating: Motor rating, service factor and nameplate data shall conform to the requirements of NEMA-MG-1 standards. Motor nameplate horsepower ratings shall not be exceeded when the equipment is operating within the limits of the design conditions specified. The motor loading shall not exceed the motor service factor rating on start-up conditions or at the equipment maximum load point.

D. Nameplate data shall conform to NEMA MG 1 requirements. For motors of one horsepower and greater, the following additional nameplate data shall be included:

1. Manufacturer’s identification number
2. Frame size number
3. Insulated system class designation
4. Service factor
5. Locked-rotor KVA code letter
6. Starting limitations (if any)
7. Hazard classification (if approved)

   a. Design and construction of each motor shall be coordinated with the driven equipment requirements.

E. Service factor - All motors of one horsepower and greater shall be furnished with a service factor of 1.15 in accordance with NEMA-MG-1.

F. Enclosures - All motors shall be self-cooled. Motors for indoor service shall have drip-proof enclosures. Motors for outdoor service shall be totally enclosed and shall have all exposed metal surfaces protected, where practical, with a corrosion resistant polyester paint or coating. Exposed unpainted and uncoated metal surfaces shall be of a corrosion resistant material. All self-ventilated open type motors and the fan hoods of totally enclosed fan cooled motors shall meet NEMA MG 1 requirements for a fully guarded machine. Totally enclosed motors shall be furnished with cast iron frames, bearing brackets and terminal housings. Fan cooled motors shall have fans fabricated of corrosion resistant metal and cast-iron fan covers.

G. Bearings for fractional horsepower motors shall be designed to operate in any position or angle. One-piece sleeve bearings with wick lubrication shall be furnished where available. Ball bearings shall be furnished where sleeve bearings are not available and where axial thrust loads exceed 20 pounds.

H. Bearings for motors of one horsepower and greater shall be oil lubricated sleeve bearings. If motor frame size is such that sleeve bearings are not available, bearings shall be grease lubricated rolling element type, self-lubricated and re-greaseable.

1.11 DISCONNECT SWITCHES

A. Material - Disconnect switches shall be NEMA type HD (Heavy Duty) quick-make, quick-break disconnect switches not furnished by others with equipment and where indicated on drawings or where required by Code. Switches shall be fusible or non-fusible as called for or as required. Switches shall have NEMA I enclosure unless otherwise specified or called for otherwise on drawings. Switches shall have door interlock and shall be padlockable in "open" and "closed" position. Where indicated for use in motor circuits utilizing VSDs switch
shall be furnished with interlock contacts for interface with VSD, preventing operation of
VSD when load is disconnected.

B. Reference E-series drawings and Division 26 for disconnect switches provided by electrical
contractor. If not shown and required it is assumed the equipment manufacturer is
providing it. If not, the contractor shall be responsible for all providing including all labor for
installation.

1.12 MOTOR STARTERS

A. Starters shall be in accordance with NEMA ICS, UL 508 and the following paragraphs:

B. All starters installed indoors shall be in a NEMA 1 enclosure and all starters installed
outdoors shall be in a NEMA 4 enclosure. Enclosures shall be designed for surface mounting
unless otherwise indicated.

C. Each starter shall have a nameplate on the cover. Nameplates shall be made of laminated
black and white plastic with the white on the outside. Lettering shall be bold, not less than
1/4-inch square, engraved through the white outside layer so that the letters appear black.
Nameplate wording will be furnished as called for on drawings or as approved by the Owners
Representative.

D. Magnetic starters shall include 480 volt, 3-phase, 60 hertz contractors with three manual
reset thermal overload relays, 120-volt operating coils, and 480 to 120-volt dry type control
transformers complete with one secondary lead fused and the other secondary lead
grounded. Large size starters which require line voltage to energize the operating coils shall
be equipped with auxiliary contractors for use in the operating coil circuit. These contractors
shall be operated from the 120-volt circuit of the control transformers. Reduced voltage
starters shall be closed transition auto transformer type equipped with taps for 50, 65 and
80 percent of full voltage. Two speed starters and reversing starters, shall be mechanically
and electrically interlocked so that only one set of contacts can be closed at any one time.
Contractors shall have a current rating in accordance with NEMA standard ICS.

E. Two each normally open and normally closed interlock contacts shall be furnished with each
starter as indicated. Additional interlocks shall be as called for on drawings.

F. Three thermal overload relays of the bimetallic strip or euthenic alloy type shall be furnished
with each motor starter. Thermal overload relay heaters shall be sized to protect their
associated motors of the circuits from damage due to overload. Provisions shall be made
for manually resetting the thermal relay without opening the starter cover.

G. Control Transformers shall have 60 hertz ratings permitting operation at a primary voltage
ranging from 208 to 240 volts. Assuming 208 volts on the primary terminals, each control
transformer shall maintain a minimum potential of 105 volts at its secondary terminals
during starter coil inrush, while simultaneously serving an additional load of 100-volt amperes at 50 percent power factor. Control transformers shall be mounted in the
enclosure with the magnetic starter.

H. Each magnetic starter shall be equipped for control from local remote push-button or
control switch, or other pilot devices as called for on drawings. All necessary internal wiring
for this feature shall be supplied and connected to terminal blocks located to provide easy
connection to the external control wiring.
I. A push to test running pilot light shall be provided and mounted in the cover of each magnetic starter to indicate when the motor is in operation. The light shall be of the transformer type with a 6-volt bulb and a red color cap.

J. "Hand-Off-Auto" Selector Switch Units shall be provided and mounted in the cover of the starter as indicated in these specifications and as indicated on drawings. Units shall be heavy-duty, oil-tight and shall be complete with contact blocks and legend plates. Momentary contact "start-stop" push-buttons shall be provided with an auxiliary contact for use in the holding circuit.

K. Schematic Diagrams shall be as indicated on drawings or as approved by the Contracting Officer.

L. Coordinate the following with article 15010.14 and the electrical engineer. Typically the mechanical contractor will not provide fusible disconnect switches. Therefore normally the following will be deleted.

M. Each combination starter where indicated on drawings shall include a magnetic starter, as specified hereinbefore, and a disconnect switch or a fusible disconnect switch complete with fuses.

1. Each fusible disconnect switch unit shall include one 3 pole, 600 volt, quick-make, quick-break, manually operated switch connected in series with one replaceable dual element fuse per switch pole. The switch and fuse elements shall be sized according to the following:

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<th>Starter Size</th>
<th>Fuse Clip Size</th>
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N. Fuses shall be UL 198D Class K5, 600 volt, and dual element type. Fuses shall have a thermal element that restricts the temperature rise to 280° F. and an element of low peak type that limits the let through fault current. Fuses shall be rated at 200,000 amperes RMS symmetrical interrupting capacity and shall have a minimum time delay of 10 seconds at 500% of rating as specified hereinbefore.

O. A manual operating handle shall be mounted in the cover of each starter to operate the disconnect switch. The handle shall have provisions to lock in the open position with one or more padlocks. The cover and switch shall be interlocked so that the cover cannot be opened normally when the switch is in the closed position. Provisions shall be made for overriding this interlock.

P. Motor starters shall be wall or column mounted not more than six feet above the floor or mounted on the equipment if readily accessible from the floor or roof. Each starter shall be labeled on the cover as specified hereinbefore. The labeling shall be done with black letters on a white background. Letters are to be 1/4 inch high.
Q. Nameplates - All major equipment items shall have a permanent stainless-steel nameplate. Nameplates shall include the applicable items in the following list:

1. Manufacturer's size and type
2. Serial number
3. Design capacity
4. Design pressure
5. Design speed
6. Design temperature
7. Design static pressure "w.c."
8. Motor horsepower and RPM

R. A permanently attached rotation arrow shall be provided on all items of rotating equipment.

PART 3 - EXECUTION

1.13 CUTTING AND PATCHING

A. The responsibility for any cutting of construction, which is required for the installation work, shall be by the Contractor. The Contractor shall coordinate with the Owner before any cutting and obtain approval from the Engineer and the Owner prior to any cutting.

B. Where openings for work within this Division are provided under other sections of the specifications, this Contractor shall be responsible for locating and providing the proper dimensions for all such openings.

C. Cutting shall be done with extreme care and in such a manner that the strength of the structure will not be endangered. Wherever possible, openings in concrete or masonry construction shall be by concrete saw or rotary core drill. Openings in any construction shall be cut the minimum size required for the installation of the work.

1. Adequate protection shall be provided to prevent damage to adjacent areas and to prevent dust from spreading to adjacent areas.
2. The use of jackhammers will not be permitted.

D. Where openings or holes are cut in existing construction and the cutting breaks existing electrical circuitry or control circuitry, or communications, conduit and wiring, then it shall be the responsibility of the Contractor to have the circuitry, conduit and rewiring re-routed and to complete the circuitry as required and as approved by the Owner. Temporary completion shall be provided where necessary before the permanent re-routing and completion work is finished. All costs for this work shall be the responsibility of the Contractor and no additions will be allowed to the Contract price.

E. Before any cutting, patching, or finishing work is started, dust and moisture protection shall first be installed as required to protect adjacent construction and equipment and to prevent dust spreading from the immediate area where work is being performed.

F. After any work is installed through any opening in walls, partitions, ceilings, or floors, the opening around the work shall be patched to match the existing construction, and the openings around pipe sleeves, and between pipes and sleeves, shall be sealed watertight through floors and shall be sealed fireproof and smoke tight through floors, walls, partitions and ceilings.
G. Where existing work is removed from openings in existing construction and the opening is not to be reused for new work, the opening shall be filled and patched to match existing adjacent construction and to be watertight for floors and to be fireproof and smoke tight for floors and all other construction.

H. No structural member shall be cut without the approval of the Consultant, and all such cutting shall be done in a manner directed by him.

1.14 EXCAVATION AND BACKFILL

A. Work shall be performed as hereinafter specified and in accordance with the requirements of Division 31 and / or Division 33. Soil stabilization shall also be in accordance with Division 31 and / or Division 33.

B. Lines shall be used to layout the trenches for all underground work and there shall be no variation from the drawings except upon written order from the Engineer. Trenches close to walls, foundations, and columns shall not be excavated without prior consultation with the Architect or Owner or his Representatives.

C. All excavations shall be properly protected by the necessary bracing and timbers to prevent any collapses or damage to adjacent improvements. Where required to prevent collapses, the sides of the trenches shall be securely held by bracing or sheathing, which bracing or sheathing shall not be removed until the level of the backfill has reached the point where such removal can be safely carried out. Where adjacent improvements might be damaged by the removal of such bracing, the braces shall be left in place to prevent such damage. The thickness of the sheathing and the dimensions of the cross braces, shoes and miscellaneous supports to be used by the Contractor shall be as required and of type to properly protect the sides of the trench and to prevent injurious collapses or erosions.

D. The Contractor shall do all pumping and bailing necessary to keep all excavations free of water and shall provide for the uninterrupted flow of the surface water adjacent to the line of work during the progress of the work. The Contractor shall inspect the ground where excavation is required to ascertain the structure of the soil.

E. The Contractor shall cut and replace all existing walks, roads, street pavement, curbs, steps, retaining walls, and miscellaneous work removed or damaged by him in connection with the piping installation, whether or not the improvement is shown on the drawings. Such repairs shall be done to the satisfaction of the Architect, and where the work is performed on public property outside of the property lines, the Contractor shall obtain permits and permission from the proper authorities, shall perform all work to comply with requirements of the enforcing authorities and shall pay all costs relating to this work as a part of the contract bid price.

F. In cases where existing water, sewer, gas, electric or other pipes or conduits are encountered, they shall not be displaced or molested unless necessary, in which case, they shall promptly be replaced in good condition. All water, sewer, gas, conduits, or electric lines damaged or molested in the construction shall be replaced or repaired at the Contractor's expense. Wherever necessary to determine the locations of existing underground utilities, pipes, conduits, cables or other structures, examine all available records and make explorations and excavations as necessary to determine the locations.
G. The Contractor shall provide all temporary bridges, barricades, lanterns and such other signs and signals as shall be necessary to warn the public of the dangers caused by excavations and other obstructions.

H. The backfilling of trenches shall be carried out as rapidly as the testing and acceptance of the finished sections of the piping installation will permit. The trench shall be backfilled in layers not to exceed 6" with good selected dry earth thoroughly tamped with pneumatic tamper. **Note:** Broken stones, cinders, frozen earth and rubbish are not acceptable for backfilling. Before backfill operations commence on any new or replacement underground utility construction work, the Contractor shall give 48 hour notification to the Architect. Such notice shall be required so that the work can be inspected.

I. After backfilling, all surplus excavated material shall be removed from the grounds, to an authorized disposal site.

J. The work shall be executed so that existing culverts, drains, catch basins, retaining walls, fences or any other permanent structure along and adjacent to the new work are properly protected. The Contractor at his own expense shall repair any damage occurring to these structures.

K. The Contractor shall make a field inspection of the location along which the underground work is to be constructed and note all obstructions and improvements at the surface and overhead, which may affect this method of operation in the construction of these lines. Such overhead wires and underground pipes or conduits, which may be existing, or which may be encountered, shall be protected by the Contractor during this construction.

1.15 ELECTRICAL COORDINATION

A. All electrical products and installation used on this project shall conform unless otherwise specifically noted, to applicable standards of the National Electrical Manufacturers Association, NFPA 70, Division 26 of these specifications, and shall also be listed by Underwriter's Laboratories, Inc. and/or other agencies, as required.

B. Electrical power sources and motor connections for all equipment shall be provided as specified within Division 26 of these specifications. All control wiring, safety interlock wiring, and temperature control system wiring required shall be furnished and installed as specified within these specifications. The control wiring shall include the furnishing and installation of all conduit, boxes, fittings, devices, accessories, wire, and connections required for complete and properly functioning systems. All wiring shall be installed in conduit, and all splices and connections shall be made in approved type enclosures or boxes.

1. If motors or controls are not shown on the Electrical Drawings, it has been assumed that these motors and controls have been wired as part of a piece of package equipment, or that control wiring will be run by the Contractor.

C. Reports: The Contractor shall submit to the Engineer, after mechanical systems are completely installed and operating under normal load conditions and prior to final acceptance of the project, four (4) copies of tabulated report on each piece of mechanical equipment motor and motor starter. The tabulated reports shall show the following information:

1. Mechanical equipment identification on which motor and starter is used
2. Motor nameplate horsepower, full load amperes, and voltage
3. Motor nameplate service factor and temperature rise
4. Actual (metered) motor running amperes and voltage
5. Motor starter nameplate: HP rating and voltage
6. Motor starter thermal overload protection unit current rating, manufacturer's name and manufacturer's catalog number marked on thermal units.

1.16 OWNERS FURNISHED EQUIPMENT

A. Contractor shall provide the following for all equipment furnished by Owner or another trade:

1. All rough-ins for equipment and accessories;
2. Installation of loose trim provided with equipment by the Equipment Supplier;
3. Furnish and install all piping connections, valves, waste outlets, traps, unions, vacuum breakers, control valves, drains and other accessories as indicated on plans and as specified here within these specifications;
4. Make all final connections including but not limited to hot and cold water, sanitary waste and vent, indirect drains, compressed air, and natural gas as required for complete and operational system as intended by these contract documents.

1.17 NOISE AND VIBRATION

A. Contractor shall be responsible for the installation of all equipment in such a manner as to control the transmission of noise and vibration from any installed equipment or system, so the sound level shall not exceed NC35, in any occupied space. Contractor shall be responsible for the correction of any objectionable noise in any occupied area due to improperly installed equipment.

1.18 INSPECTION

A. Each bidder shall inspect the site as required for knowledge of existing conditions and failure to obtain such knowledge shall not relieve the successful bidder of the responsibility to meet existing conditions in performing the work under the contract.

B. Where new work cannot be installed without changes to the existing facility, facility or systems or where it is indicated on drawings to rework an existing installation, this contract shall include alterations to existing work as required to install new work. Additions to the contract cost will not be allowed because of this Contractor's failure to inspect existing conditions.

1.19 TESTING

A. All electrical equipment furnished under this Division shall be adjusted and tested by this Contractor. Motors and other equipment furnished by others, to which electrical connections are made under this Division, shall be checked for short circuit and open circuits before energizing. Motors shall be checked for proper phasing and rotation. The thermal overload protection devices shall be checked in all motor starters, and equipment and all protection device size, motor nameplate full load amperage, and voltage rating for protection of the motor shall be listed (include equipment designation, rating of heater, motor nameplate horsepower, full load amps and voltage) and 4 copies of list shall be submitted to the Architect.
B. Mechanism of all electrical equipment shall be checked, adjusted and tested for proper operation. Protective devices and parts shall be checked and tested for specified and required application and adjusted as required. Adjustable parts of all lighting fixtures and electrical equipment shall be checked, tested and adjusted as required to produce the intended performance.

C. Completed wiring systems shall be free from short circuits and after completion, perform tests for insulation resistance in accordance with the requirements of the National Electrical Code.

D. The Contractor shall be held responsible for the operation, service and maintenance of electrical equipment during construction and prior to acceptance by the Owner. All electrical equipment shall be maintained in the best operating condition. Operational failure caused by defective material and/or labor furnished under this Division shall be immediately corrected. Architect shall be immediately notified of any operational failures caused by defective material and/or labor covered under other Divisions or furnished by others.

1.20 START-UP

A. All labor for the installation of material and equipment furnished under this Division shall be done by experienced mechanics of the proper trade and all workmanship shall be first class and in compliance with the specific requirements of drawings and specifications.

B. All material and equipment provided under this Division shall be installed under competent supervisory service furnished by the Contractor. Where necessary, this shall include the services of special erection and operation personnel.

C. The Contractor shall furnish all hoists, scaffolds, staging, runways, tools, machinery and equipment required for the performance of work.

D. Dirt and refuse resulting from the performance of the work shall be removed from the premises daily as required (broom clean) to prevent accumulation and the Contractor shall cooperate in the maintaining of reasonably clean premises at all times.

E. Immediately prior to the final inspection, Contractor shall clean all material and equipment. Dirt, refuse and stains shall be removed from all surfaces and damaged finishes restored to original condition.

1.21 TRAINING

A. The Contractor shall furnish all services as required for adequate verbal and printed instructions to the Owner and the Owner’s operating and maintenance personnel for operation and maintenance of all equipment and systems installed under this Division. Three complete copies of service manuals in hardback binder shall be furnished at the end of the project in accordance with the General Conditions of the specifications. The manuals shall include printed operating and maintenance instructions for systems and equipment specified under this Division, all approved shop drawings and all manufacturer printed data.

B. When the work is complete and at a time designated by the Owner’s designated Representative, the Contractor shall furnish the services of a qualified instructor to instruct the Owner’s personnel in the operation and maintenance of the systems and equipment.
C. The bound copies of the operating and maintenance manuals shall be used during the verbal instructions.

END OF SECTION 220500
SECTION 220501 - PLUMBING PROJECT COORDINATION AND INSTALLATION

PART 1 - GENERAL

1.1 VISIT TO SITE OF WORK

A. Visit site and survey existing conditions affecting work prior to bid. Include necessary materials and labor to accomplish the work, including relocation of existing services and utilities on building site in bid. No consideration shall be given to future claims due to existing conditions. Any discrepancies or interference shall be reported immediately to Owner/Consultant.

1.2 CONTRACTOR’S USE OF PREMISES

A. Confine operations at site to areas and limits permitted by law, ordinances, permits; Contract Documents and GENERAL CONDITIONS.

B. Protection and safekeeping of products stored on premises is responsibility of contractor supplying product.

C. Deliveries and unloading shall be scheduled to prevent traffic congestion blocking of access or interference with Work. Arrange deliveries to avoid larger accumulations of materials than can be suitably stored at site.

D. Contractor shall pay for, or satisfactorily repair, all damages incident to their Work, to sidewalks, streets, other public or private property, or to any public utilities occurring during period of work under this Contract.

PART 2 - EXISTING FACILITY REQUIREMENTS

2.1 HAZARDOUS MATERIALS

A. Submit Material Safety Data Sheets for all materials furnished in this project defined as hazardous by NFPA. All requirements of the Material Safety Data Sheets shall be implemented and followed judiciously when hazardous materials are installed or otherwise used.

B. All hazardous materials shall be stored and used (mixed, applied, etc.) in strict accordance with the OSHA Standards, Safety Data Sheets and the Owner’s Safety standards.

C. Refrigerants, nitrogen, welding gas, paints, varnish, volatile oils, etc., shall be stored in a room having good ventilation and containing no other material, or in metal lockers or barrels well away from structures or other combustible materials.

2.2 WELDING AND CUTTING

A. Special precautions shall be taken to reduce fire hazards where electric or gas welding or cutting work or soldering is done and suitable fire extinguishing equipment shall be maintained near such operations. Before proceeding with any electric or gas welding or cutting or soldering work in or adjacent to the existing building the Contractor shall obtain a
permit from either the Engineer or Owner. The permit shall be issued by its authorized supervisor or representative certifying compliance with conditions set out in the permit pertaining to welding and cutting operations.

END OF SECTION 220501
SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Flexible-hose expansion joints.
   2. Pipe bends and loops.
   3. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

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

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS

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

B. 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 bends
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer’s number, size, material, pressure rating, end connections, and location for each expansion joint

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths

1. Manufacturers:
   a. Flexicraft Industries.
   b. Flex-Pression, Ltd.
   c. Metraflex, Inc.

2. Retain one of first two subparagraphs below to suit pressure and temperature requirements of systems in which these devices are installed. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder joint end connections

   a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder joint end connections.

   a. NPS 2 and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Manufacturers:
   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Flex-Weld, Inc.
   d. Metraflex, Inc.

2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
C. Washers: ASTM F 844, steel, plain, flat washers.

D. 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.
   2. Expansion Plug: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION
   A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
   B. Install expansion joints of sizes matching size of piping in which they are installed.
   C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION
   A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
   B. Attach pipe bends and loops to anchors.

3.3 ALIGNMENT-GUIDE INSTALLATION
   A. Install guides on piping adjoining pipe expansion fittings and loops.
   B. Attach guides to pipe and secure to building structure.

3.4 ANCHOR INSTALLATION
   A. 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.
   B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
   C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
   D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints are indicated.
   E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.
SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gauges.
4. Gage attachments.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Product certificates.
C. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flo Fab Inc.
   b. Trerice, H. O. Co.
   c. Weiss Instruments, Inc.

2. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Stem: Stainless steel and of length to suit installation, including insulation thickness.
   a. Design for Thermowell Installation: Bare stem.

8. Connector: 1.25 inches, with ASME B1.1 screw threads, with adjustment of up to 180 degrees in vertical plane.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Type: Stepped shank unless straight or tapered shank is indicated.
5. Internal Threads: 0.5, with ASME B1.1 screw threads.
6. Bore: Diameter required to match thermometer bulb or stem.
7. Insertion Length: Length required to match thermometer bulb or stem.
8. Lagging Extension: Include on thermowells for insulated piping and tubing.
9. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.3 PRESSURE GAUGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:
   1. Subject to compliance with requirements, provide products by one of the following:
      a. Ashcroft Inc.
      b. Trerice, H. O. Co.
      c. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   2. Case: Liquid-filled Sealed type(s); cast aluminum; 4.5-inch normal diameter.
   3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   4. Match pressure connection size in first subparagraph below with gage attachment size.
   5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type
      unless back-outlet type is indicated.
   6. Movement: Mechanical, with link to pressure element and connection to pointer.
   7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
   10. Ring: Metal.
   11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston-type
   surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter to center of pipe and
   in vertical position in piping tees.
B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gauges in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gauges on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install thermometers in the following locations:
   1. Incoming domestic water service.

K. Install pressure gauges in the following locations:
   1. Building water service entrance into building.
   2. Inlet and outlet of each pressure-reducing valve.
   3. Suction and discharge of each domestic water pump.

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

M. Adjust faces of meters and gauges to proper angle for best visibility.

3.2 THERMOMETER SCHEDULE

A. Thermometers at incoming domestic water service shall be the following:
   1. Industrial-style, liquid-in-glass type.

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

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.

B. Scale Range for Domestic Hot-Water Piping: 30 to 300 deg F.

3.4 PRESSURE-GAUGE SCHEDULE

A. Pressure gauges at discharge of each water service into building shall be the following:
   1. Liquid-filled, direct-mounted, metal case.
B. Pressure gauges at inlet and outlet of each water pressure-reducing valve shall be the following:
   1. Liquid-filled, direct-mounted, metal case.

C. Pressure gauges at suction and discharge of each domestic water pump shall be the following:
   1. Liquid-filled, direct-mounted, metal case.

3.5 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 160 psi.

B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION 220519
SECTION 220523 - PLUMBING VALVES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Plumbing Valves:
   1. Ball Valves
   2. Globe Valves
   3. Check Valves
   4. Plug Valves

B. Pressure and Temperature Relief Valves

1.2 QUALITY ASSURANCE

A. Valves shall be of the same manufacture throughout, where possible. Manufacturer’s name and pressure rating shall be located on outside of valve.

B. Unless noted otherwise, cut-off valves shall be ball valves or butterfly valves, as more specifically described below. Flow control (balancing) valves shall be per Section 221119 – Domestic Water Piping Specialties.

C. Cut-off valves used in water and/or air systems including domestic water (cold, hot, and circulation) and compressed air shall be ball valves for 2” size and smaller, and shall be butterfly valves 2½” size and larger.

1.3 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1, Section 013300, and as follows:
   1. Submit copies of valve ordering schedule for approval before ordering valves.
   2. Submit detailed shop drawings indicating make, model, location, type, size, and pressure rating.

PART 2 - EQUIPMENT

2.1 BALL VALVES

A. Ball valves shall be manufactured to comply with MSS SP 110 and shall be 3-piece type. Valves shall be all bronze (B-584 or B-62) with stainless steel ball, full port and shall be designed for 150 PSI, 600 WOG; working temperature range of at least 0°F. to 300°F. Ball valves shall be three-section assembly with Double-O ring seal and removable center section with replaceable Teflon, TFE seats. Ball valves shall have blow-out proof stem with high extended stem to provide for insulating, lever type handle with vinyl grip and 90° stop on the extended stem. All valve stem housings shall be of length to receive up to 1½” thick insulation and shall have NIB seal valve extension.

B. Manufacturer
1. Ball valve manufacturers for plumbing applications
   a. Ball valves in water piping shall be NIBCO T595-66 or approved equal.

2.2 GLOBE VALVES

   A. Globe valves in piping 2" and smaller shall be bronze, rated at 150 psig-swp and provided with a union bonnet, composition disc and screwed ends.

   B. Globe valves in copper tubing shall be bronze, rated at 300 psig-wog, and provided with a screwed bonnet, composition disc, solder ends.

   C. Globe valves in piping 2½" and larger shall be iron body, bronze mounted, rated at 125 psig-swp and provided with a composition disc, outside screw and yoke and flanged ends.

   D. Manufacturer (Basis of Design)
      1. Globe valves in piping 2" and smaller shall be Stockham B-22.
      2. Globe valves in copper tubing may be Stockham B-14T.
      3. Globe valves in piping 2½" and larger shall be Stockham G-514T.
      4. Equals include NIBCO and McDonnel

2.3 CHECK VALVES

   A. Swing check valves in piping 2" and smaller shall be Stockham B-319, or NIBCO T413-Y, bronze, rated at 125 psig-swp and provided with a bronze disc and screwed ends.

   B. Swing check valves in copper tubing may be Stockham B-309, or NIBCO F918-B, bronze, rated at 125 psig-swp and provided with flanged ends.

   C. Swing check valves in piping 2½" and larger shall be Stockham G-931 or NIBCO F918-B iron body, bronze mounted, rated at 125 psig-swp and provided with flanged ends.

   D. Checks in vertical piping shall be Jenkins 119, or approved equal, with bronze bodies and bronze discs guided at top and rated at 150 psig-swp.

2.4 PLUG VALVES

   A. Materials: 175 psi, eccentric design, cast iron ASTM A 126 Gr. B body, grooved ends, ductile iron ASTM A 536 plug encapsulated with a resilient material, self-lubricating, multiple packing ring stem seal, welded in nickel overlay seats, and lever or gear operator.

   B. Manufacturers: Stockham or NIBCO.

2.5 PRESSURE & TEMPERATURE RELIEF VALVES

   A. Material - Pressure and temperature relief valves shall designed, constructed and rated to ASME Code. Valves shall have a capacity at pressure indicated on drawings, in Btu's/Hr. of not less than capacity of units which they protect and they shall have test levers. Extend relief line full size and end over drain.

   B. Manufacturer
PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Valves shall be installed within each system to provide the required flow control and to provide isolation for inspection, maintenance and repair of each piece of equipment and each main and branch service loop. The foregoing shall apply whether or not valves are shown on drawings. Valves shall also be installed in other locations shown on drawings. Each valve shall be installed so as to be easily accessible for operation and visual inspection after construction is complete.

1. A union connection shall be installed within two feet and on each end of a screw end valve (Reference Section 221119 for piping unions). Valves and specialty items shall be rated for not less than the cold water working pressure and the test pressure specified for each piping system.

END OF SECTION 220523
SECTION 220529 - PLUMBING SUPPORTS, ANCHORS, AND SEALS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Piping Hangers and Supports

B. Roof Mounted Curbs and Equipment Supports

PART 2 - EQUIPMENT

2.1 PIPING HANGERS AND SUPPORTS

A. Provide factory-fabricated horizontal piping hangers, clamps, attachments and supports in compliance with ANSI SP-69 and ANSI SP-89. Select hangers and supports sized to exactly fit pipe size for bare piping, and to exactly fit around pipe insulation with saddle and shield for insulated piping. Hangers in contact with copper pipe shall be copper plated.

B. Unless specified otherwise, pipes shall be hung with malleable iron, split ring hangers or clevis hangers not less than 1/8" thick. Strap type hangers shall not be acceptable. Roller type hangers shall be used where required or shown to allow for movement of pipes by expansion. Hangers shall have rods and turnbuckles of required length. Suspension shall be from suitable steel supports fastened to overhead construction or steel wall brackets. Hangers and supports shall be installed so that pipes are run parallel and evenly spaced.

C. Anchors in concrete construction shall be threaded compound type or Phillips self-drilling type of sufficient size to adequately support the load.

D. Manufacturer:

1. Hangers and supports:
   b. Kindorf Mfg.
   c. Unistrut Mfg., Inc.
   d. Fee Mfg.

2. Saddles and shields:
   a. Pipe Shields, Inc.

2.2 ROOF MOUNTED CURBS AND EQUIPMENT SUPPORTS

A. Curbs and equipment supports for roof mounted equipment shall be of monolithic construction, not less than 18 ga. galvanized steel, with continuous welded corner seams, factory installed wood nailer, built-in raised cant of height as required for thickness of roof insulation, and base as required for attaching to the roof structure.

B. Curbs shall be internally insulated with 1½" thick, 3 lb. density rigid glass fiber board and shall have galvanized sheet metal liner. Equipment supports shall have integral base plate, wood nailer, and 18-gauge galvanized steel flashing cap.
C. Curbs and equipment supports shall be of size as required to properly mate with equipment to be mounted on the curbs or supports and shall be designed and constructed to safely support the weight of the equipment. The height of curbs shall be as indicated on drawings, but not less than 13½" high above the roof deck, unless called for or specified otherwise.

D. The curbs and supports shall be securely attached to the roof structure to withstand wind pressures on the vertical surface of the curb or supports and the mounted equipment by wind velocities up to 100 MPH. The complete installation shall be made watertight and shall be coordinated with the roofing installer.

E. Manufacturers:
   1. Roof Curbs
      a. Pate Manufacturing Company: PC-2
      b. Thycurb
      c. Custom Curb
   2. Equipment Supports
      a. Pate Manufacturing Company: ES-5A
      b. Thycurb
      c. Custom Curb

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Comply with MSS SP-69 and SP-89 for installation of hangers, supports and anchors. Install hangers, supports, clamps, and attachments directly from building structure complete with inserts, bolts, rods, nuts and washers, and washers, and accessories. Do not use wire or perforated metal to support piping; pipe support from other piping shall not be permitted. Install hangers with minimum ½" clear space between finished covering and adjacent work. Place hanger within 1 foot of each horizontal elbow. Use hangers vertically adjustable 1½" minimum after piping is erected.

B. Insulated pipe, hangers and supports shall be furnished with ribbed galvanized steel shields of not less than 18 gauge; two-piece pre-molded, high compressive strength, insulation inserts (360° around pipe); and vapor barrier jacket covering the insulation inserts. Inserts shall be constructed of high density, 100 psi, waterproofed calcium silicate, encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation.

C. Maximum spacing of hangers and supports shall be in accordance with the following schedule for size of pipe:
D. Hangers for cast iron pipe shall be installed on maximum 5'-0" centers.

E. Supports on masonry walls shall have bolts through wall fastened to suitable steel plate on back of wall. Where required to allow for movement of pipe by expansion due to short hanger rods, pipes shall rest on rollers and covering protection saddles. All piping shall be supported and secured as required to prevent vibration and the transmission of noise and lateral movement.

F. The Contractor shall furnish and install all necessary material, hangers and support including all structural steel members and shapes to substantially support and/or suspend all piping and equipment, in an approved manner. Perforated strap hangers will not be acceptable.

G. Drive screws, pins, studs, etc., which are secured in place by means of explosive force will not be permitted. Except as specifically otherwise approved, no item of equipment shall support any pipe or duct nor shall any item of equipment be supported on any pipe or duct.

H. Hangers shall be provided at every item of equipment and at every change in direction or branch connection to every pipe.

I. All pipes through roof shall be installed with sleeves and openings, and with roof flashing/counterflash assembly or pipe curb assembly as herein specified. The complete installation shall be coordinated with the roofing installer and shall be watertight and weather tight.

J. Sleeves shall be steel pipe and shall be installed for single pipe installation. Openings shall be boxed out for multiple installations. Sleeves for acid waste vent stacks shall be installed as specified under the heading: Sleeves and Openings.

K. Single, un-insulated pipes through roof shall be installed with flashing/counterflashing assembly with four pound seamless lead flashing assembly with 8" high boot and not less than 8" skirt. A conical shaped steel reinforcing boot underneath lead flashing assembly shall also be installed. Cast iron counterflashing fitting with rust-resistant prime coat, of the
Caulking type to fit over all types of piping, vandal-proof set-screws for anchoring in place, and top annular space for sealant fill shall also be installed for single, un-insulated pipes. Assemblies shall be furnished in sizes to properly fit size of pipe with which they are installed. Flashing assembly shall be designed to fit properly on roofs from level up to 20° pitch. Top of flashing cone shall be sealed before installing counterflash fitting. Annular space in top of counterflash fitting shall be completely filled with epoxy sealing compound.

L. Grouped multiple pipes through roof and insulated pipes through roof shall be installed with factory prefabricated metal curb assembly of unitized construction of not less than 18 ga. galvanized steel with base plate for anchoring to roof deck or roof slab. The cant base for roof insulation thickness shall match the thickness of insulation where it is to be installed. A wood nailer strip shall be installed on top of the curb, and shall have 1½” thickness of 3 lb. density fiberglass insulation on inside, and not less than 11” high from base to top of wood nailer. The curb assembly shall also have an acrylic clad ABS plastic flashing cover with number and size of formed openings as required for the number and size pipes through roof, along with a graduated step neoprene boot for each pipe. A neoprene boot shall be secured around pipe and around formed opening in flashing cover with stainless steel clamps for waterproof connections. Insulation on insulated pipes shall be continuous through the curb, flashing cover, and the neoprene boot. After roofing is flashed up over the curb and secured in place, the ABS plastic flashing cover shall be installed over curb and flash roofing and anchored in place for a watertight and weather tight installation.

M. Furnish and set all boxouts for openings and all sleeves for work to be installed under this division. Sleeves shall be installed for all pipes passing through floors, walls, and partitions. All sleeves shall be set tight in construction, without space between the sleeve and construction. Sleeves through walls and partitions shall be flush at each end and sleeves through floor shall extend 2” above finished floor unless indicated otherwise.

N. Sleeves through concrete slabs, concrete walls, and bearing masonry walls shall be steel pipe of not less than Schedule 30. Sleeves through non-bearing wall and partitions may be Schedule 10 pipe or 22 ga. sheet steel with formed bead on each end.

O. The annular space around bare pipes and pipe insulation on insulated pipes through sleeves shall be packed tightly with mineral wool to prevent transmission of air and sound. Each end of sleeve at floors and through fire-rated walls shall also be sealed with 1” thickness of waterproof and fireproof caulk equivalent to 3M #CP25 fireproofing caulk.

P. Each Contractor shall provide all structural steel and materials necessary to properly support and anchor equipment and lines provided under this contract.

Q. All equipment and materials shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and suitable for the service required.

R. Concrete bases shall be provided where shown on the drawings. Equipment which is to be grouted in place shall be grouted with Embeco or approved non-shrink grout.
SECTION 220548 – PLUMBING VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding and restrained spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: B
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [I]
   a. Component Importance Factor: 1.0
   b. Component Response Modification Factor: 1.5
   c. Component Amplification Factor: 1.0

1.3 SUBMITTALS

A. Product Data: For each product indicated.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and 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.

C. Welding certificates.

D. Qualification Data: For professional engineer.

E. Field quality-control test reports.

1.4 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, preapproved by ICC-ES, or preapproved 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.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Isolation Technology, Inc.
3. Mason Industries.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mount: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. 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.

F. 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.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.

H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

K. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 SEISMIC-RESTRAINT DEVICES

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

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Hilti, Inc.
5. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications 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, swivel, 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 to hanger rod.

F. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in 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. Minimum length of eight times diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.

B. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. 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.

F. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 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 post-connection testing has been approved), and with at least seven days' advance notice.


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.


7. Measure isolator deflection.

8. 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.

3.4 ADJUSTING

A. Adjust isolators after piping system 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 220548
SECTION 220553 - PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Identification for:

1. Piping systems
2. Valves
3. Equipment
4. Warning signs
5. Painting

1.2 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1, Section 013300.

B. Submit copies valve schedule for each piping system, typewritten and reproduced on bond paper. Tabulate valve number, piping system, system abbreviation, location of valve and variations for identification. Mark valves which are intended for emergency shut-off and similar special uses, by special “flag”, in margin of schedule. Include valve schedules within Maintenance Manuals (Re: 220500) and Division 1.

PART 2 – EQUIPMENT

2.1 IDENTIFICATION MATERIALS

A. Valve tags: 19 gauge polished brass, 1-1/4” diameter, stamp engraved black enamel fitted. Valve tag fastener shall be solid brass chain.

1. At Contractors option, valve tags may be 3/32” thick engraved plastic laminated valve tags, within piping system abbreviation in 1/4” high letters and sequenced valve numbers 1/2” high letters, and with 5/32” hole for fastener. Valve tag shall be white with black lettering.

B. Valve schedule frames: For each page of valve schedule, provide glazed display frame with screws for removable mounting on masonry walls. Frame shall be extruded aluminum with SSB-grade sheet glass.

C. Engraved plastic-laminate signs: Engraving stock melamine plastic laminate; sizes and thicknesses indicated; engraved with engraver’s standard letter style of sizes and wording indicated; punched for self-tapping stainless steel fasteners. Laminated signs thickness shall be 1/16” for units up to 20 sq.in. or 8” length and 1/8” for larger units. Laminated tags and signs shall be color coded, conforming to the following color code:

1. Yellow: Heating equipment and components.
2. Green: Monitoring (space temperature and humidity)
3. White: Equipment and components that do not meet any of the above criteria.
4. Red: Warning or Danger.
2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

E. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

F. Lettering Size: At least 3/4 inches high.

PART 3 – EXECUTION

3.1 PREPARATION

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

3.2 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule shall be per the following table:

<table>
<thead>
<tr>
<th>Pipe System</th>
<th>Legend</th>
<th>Letter Color</th>
<th>Background Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softened Water</td>
<td>SFT</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Potable Cold Water</td>
<td>CW</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Potable Hot Water</td>
<td>HW</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Potable Hot Water Circulation</td>
<td>ICW</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>FP</td>
<td>White</td>
<td>Red</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>AIR</td>
<td>White</td>
<td>Blue</td>
</tr>
</tbody>
</table>
3.3 UNDERGROUND PIPING IDENTIFICATION

A. During back-filling/top soiling of exterior underground piping system, install a continuous plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench, and do not exceed overall width of 16", install single line marker.

3.4 VALVE IDENTIFICATION INSTALLATION

A. Valve tag location: Provide valve tag on all valves, cocks, and control devices in each piping system. List each tagged valve in valve schedule for each piping system. Mount valve schedule frames and schedules in machine room where directed by Owner's Representative.

3.5 EQUIPMENT IDENTIFICATION

A. Install engraved plastic laminate signs except where lettering larger than 1" is required for proper identification. Locate signs in or near each piece of mechanical equipment and each operation device.

1. Provide plastic laminated signs at main control and operating [valves, pumps, meters, gauges, thermometers, control devices, and sensors].

2. Laminated tags, at a minimum, shall be provided for each piece of equipment scheduled on drawings.

B. All temperature sensors, differential pressure switches, and control devices integrated with the building control systems shall be permanently marked to indicate normal operating points or range for both summer and winter operation. Coordinate with Engineer and Owner prior to marking. In addition, all room sensors shall have laminated tags mounted adjacent to the room sensor on wall or within the cover of the sensor itself. The laminated tag shall indicate the device which the sensor serves.

3.6 WARNING AND DANGER SIGNS

A. Where identifications signs are required to indicate a warning or danger, signs shall be plastic laminated with red background and white lettering. At a minimum warning signs shall be provided as follows:

1. All motor driven equipment that automatically starts shall include a warning sign indicating such. Coordinate wording of danger sign with facility manager.

3.7 PAINTING

A. All exposed steel, including structural members for mechanical equipment, piping, structural steel bases, and all other non-ferrous metals, shall be painted with a high solids epoxy coating manufactured by Ameron - Amerlock-400 or approved equal. Apply epoxy coating in accordance with manufacturers written instructions.
B. All painting that will be exposed to weather shall be painted with Aliphatic Polyurethane manufactured by Ameron - Amersheild or approved equal. All painting shall be applied in accordance with manufacturers written instructions.

END OF SECTION 220553
SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Piping Insulation (Glass Fiber Type)

1.2 RELATED DOCUMENTS

A. American Society for Testing and Materials

1. Flame Spread: 25 or less; ASTM E84, NFPA 255
2. Smoke Developed: 50 or less; ASTM E84, NFPA 255

1.3 QUALITY ASSURANCE

A. Insulation shall not be applied until all piping has been tested and approved and thoroughly cleaned. All insulation work shall present a neat appearance with smooth and uniform surfaces. Work done in a slovenly manner will not be acceptable. All insulation joints shall be carefully fitted and tightly butted. All jacket materials shall be neatly applied with smooth surfaces and shall be securely adhered or pasted in place. All seams and joints shall be located so that they are as inconspicuous as possible. Exposed edges and ends of all insulation shall be sealed and finished to provide a complete, unbroken vapor seal. The Contractor shall install insulation to be continuous through pipe sleeves.

B. Failure, due to faulty workmanship or material, of any portion of the installed insulation to perform the function as intended by these specifications, either stated or implied, for a period of one (1) year after acceptance of the project by the Owner, shall be the responsibility of the Contractor and shall be rectified at no additional cost to the Owner. This shall include the loosening of any jacket material, the appearance of condensation on the outside of the insulation, or any other mechanical or thermal failure which affects either appearance or efficiency of installation.

1.4 SUBMITTALS

A. Submit shop drawings for all insulating materials in accordance with Division 1.

B. Shop Drawings:

1. Submit shop drawings which indicate complete material data, mastics, adhesives, list of materials proposed for this project and indicate thickness of material for individual services.

C. Product Data:

1. Provide current manufacturer’s data to show compliance with these specifications and governing regulations; include proof of compliance for test products of products for fire and smoke rating, corrosiveness and compressive strength.
PART 2 – EQUIPMENT

2.1 PIPE INSULATION (GLASS FIBER TYPE)

A. Material – Pipe insulation including fittings and devices, unless specified otherwise, shall be insulated with 1-piece rigid molded glass fiber, 4 lbs/cu ft density with a K value of 0.22 at 75°F. The insulation shall be suitable for temperatures of −40° to 450°F, and with longitudinal flap, butt joint end strips and factory applied pressure sealing lap adhesive.

B. Manufacturers:

1. Insulation:
   a. Certain-Teed: CSG Snap-On ASJ-SSL Products
   b. Knauf: Pipe Insulation
   c. Manville Corp.: J-M Micro-Lok, 650 APT
   d. Owens-Corning: One-Piece Fiberglass 25

2. Fitting Covers:
   a. Certain-Teed: Snap-On Products
   b. Insul-Coustic: Insul-Sure Heavy Density Birma
   c. Manville Corp.: Zeston, One Piece Pre-molded
   d. PVC Cover with Fiberglass Insert.

2.2 PVC JACKETING

A. Provide PVC Jacketing on all pipe insulation located below the ceiling line in non-mechanical spaces. Cover pipe fittings and other equipment from an outside diameter of 1-5/8" to 24" in accordance with ASTM C-585.

B. PVC jacketing material shall be gloss white outdoor and spray down weatherable. Fittings, unique shapes fit screwed, welded and flanged elbows, tees, valves, couplings, laterals, reducers and end caps. The Jacketing shall be 0.020" minimum thicknesses. The Jacketing and Fitting Covering Systems include solvent weld adhesives, stainless steel tack fasteners, silicone caulking and adhesive tapes. A die-cut multi-temperature fiberglass insulation insert is available and sized for a full insulation over the exposed pipe fitting and under the overlay of the PVC Fitting Cover.

1. Code Compliance: PVC Fitting Covers and Jacketing meet: Military Specification LP-1035A, Type 11 Grade GU and Type 111, and LP-535E, Type 11 Grade GU and Type 111. Federal Specification HH-I-558, Form B, Type 1 Class B. Requirements of USDA and FDA for use in facilities of the food processing, beverage and pharmaceutical industries. PVC jacketing 25/50 fire class per ASTM E-84. Thermal conductivity of 0.26 BTU/hr/sq ft/°F/In

2. The system shall have an applicable temperature range of -35°F to 500°F (-37°C to 260°C).
PART 3 – EXECUTION

3.1 METHOD OF INSTALLATION

A. Systems shall be completely covered throughout, including valves, fittings and accessories. Strainer covers and valve bonnets shall be accessible for maintenance. Unless specified otherwise, insulation shall extend continuous through sleeves. Where pipe covering terminates at ceilings, wall and equipment, furnish and install covering protector cups fastened to covering. Cups shall be Zeston polyvinyl chloride (PVC), or approved equal.

B. All adhesives, tape and any other material used for sealing shall be applied in strict accordance with manufacturer's instructions which includes covering rate of application, method of application, temperature limits for application of said materials, or any other condition affecting efficiency or permanence of the installation.

C. Where pipe hangers are present, insulated pipe shall be furnished with ribbed galvanized steel shields of not less than 18 gauge, two-piece pre-molded, high compressive strength, insulation inserts (360° around pipe), and vapor barrier jacket covering the insulation inserts. Inserts shall be constructed of high density, 100 psi, waterproofed calcium silicate, encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation.

D. Service access shall be provided through insulation where required. Insulation at flanged joints shall be designed to permit removal of flange bolts and nuts. Insulation for removable flanges of cold pipe strainers shall be fabricated with built-up sections of fiberglass pipe covering arranged to facilitate servicing of the strainer. Applications shall be complete with vapor seals.

3.2 PIPE INSULATION (GLASS FIBER)

A. Installation shall be in strict accordance with the manufacturer's instructions. Jacket shall have finish so as not to require field painting, but shall be suitable for field painting if desired.

B. Fittings, valves and accessories shall be insulated with PVC fitting covers with glass fiber inserts to provide same insulating values as the pipe insulation in locations where piping is exposed to view. Strainer covers and valve bonnets shall be accessible for maintenance. Fitting covers on "cold" pipe requiring vapor barrier jackets shall be installed vapor tight using adhesive and "Z"-tape applied to the circumferential joints, overlapping the fitting cover and adjacent insulation jacket. No tacks shall be used on vapor tight fitting covers.

C. Where piping is concealed by construction, the fittings, valves, and accessories shall be insulated with PVC covers as specified for exposed piping. Strainer covers and valve bonnets shall be accessible for maintenance.

D. Use of staples is prohibited, except staples may be used in the longitudinal joints. If after staples are installed, the entire longitudinal joint shall be covered with 3" wide adhesive backed strip to match insulation jacketing to cover staples and securely attached.
E. Piping to be insulated and thickness of insulation shall be as follows:

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Pipe Sizes</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Cold Water, Hot Water, and Hot Water Circulation</td>
<td>Thru 2&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td></td>
<td>2½&quot; &amp; Larger</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>Roof Drain</td>
<td>All</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

3.3 ACCESSORIES

A. Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers recommended by insulation manufacturer for application indicated. Do not use staples on cold water insulation. Provide adhesives, cements, sealers, mastics and protective finishes recommended by insulation manufacturer for application indicated.

3.4 OUTDOOR PROTECTION

A. All outdoor insulation shall be covered with a weather protective jacket consisting of 22 gage aluminum or 26 gage stainless steel protective covering. Edges of exterior jacket shall be securely closed around insulation to prevent rain, snow, dirt, etc. from damaging the underlying insulation in any fashion.

END OF SECTION 220719
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Copper Tube and Fittings.
4. Dielectric Fittings.
5. Flexible connectors.
7. Sleeves and sleeve seals.

B. Related Section:

1. Division 22 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.2 SUBMITTALS

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

B. Field quality-control reports.

1.3 QUALITY ASSURANCE

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

B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L.

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.
2.3 SPECIALTY VALVES

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

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

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
   1. Description:
      a. Pressure Rating: 150 psig at 180 deg F.
      b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Couplings:
   1. Description:
      a. Galvanized-steel coupling.
      b. Pressure Rating: 300 psig at 225 deg F.
      c. End Connections: Female threaded.
      d. Lining: Inert and noncorrosive, thermoplastic.

D. Dielectric Nipples:
   1. Description:
      a. Electroplated steel nipple complying with ASTM F 1545.
      b. Pressure Rating: 300 psig at 225 deg F.
      c. End Connections: Male threaded or grooved.
      d. Lining: Inert and noncorrosive, propylene.

2.5 FLEXIBLE CONNECTORS

A. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.6 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.
2.7 SLEEVES

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

B. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.8 SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.9 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gauges for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

E. Install shutoff valve immediately upstream of each dielectric fitting.
F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Retain first paragraph below if water meters are inside the building.

I. Rough-in domestic water piping for water-meter installation according to utility company’s requirements.

J. Retain first paragraph below if piping is required to withstand seismic design loads.

K. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices as required by local authority.

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

M. 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.

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

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

P. Install piping to permit valve servicing.

Q. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

R. Install piping free of sags and bends.

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

T. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

U. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gauges for Plumbing Piping" for pressure gages.

V. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

W. Install thermometers on outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gauges for Plumbing Piping" for thermometers.
3.2 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

C. Brazed Joints for Copper Tubing: Comply with CDA’s “Copper Tube Handbook,” “Brazed Joints” chapter.

D. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA’s “Copper Tube Handbook.”

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.3 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
   1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

D. Install flow control valve in each hot-water circulation return branch and discharge side of each pump and circulator. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.
3.4 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing. Piping, piping materials, component arrangement and installation procedures must provide and accommodate points at which dielectric breaks fully segregate dissimilar metals.

B. Dielectric Fittings for 2 inches and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for 2.5 inches and larger: Use dielectric flanges.

3.5 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.6 HANGER AND SUPPORT INSTALLATION

A. Retain first paragraph below if Project is in a seismic area.

B. Comply with requirements in Division 22 Section "Plumbing Supports, Anchors and Seals" for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
3. Base of Vertical Piping: MSS Type 52, spring hangers.

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

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 0.375-inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters per schedule listed in Division 22 Section "Plumbing Supports, Anchors, and Seals".

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

G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

B. Install piping adjacent to equipment and machines to allow service and maintenance.
C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve and backflow prevention device as shown on plans; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

3.9 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 0.25-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
   a. Extend sleeves 2 inches above finished floor level.
   b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   a. Steel pipe sleeves for pipes smaller than NPS 6.
   b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
   c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Exterior Concrete Walls:
   a. Steel pipe sleeves for pipes smaller than NPS 6.
   b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
   c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.10 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Plumbing Identification" for identification materials and installation.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three (3) hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.14 VALVE SCHEDULE

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

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.

2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.


B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated water mixing valves.
7. Hose bibbs.
8. Wall hydrants.
10. Water hammer arresters.
11. Trap-seal primer valves.

1.2 PERFORMANCE REQUIREMENTS

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

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.
C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. NSF Compliance:

2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

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

   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Rain Bird Corporation.
e. Toro Company (The); Irrigation Div.
g. Zurn Plumbing Products Group; Wilkins Div.

B. Hose-Connection Vacuum Breakers:

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

   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. Prier Products, Inc.
   e. Woodford Manufacturing Company.
   f. Zurn Plumbing Products Group; Light Commercial Operation.
   g. Zurn Plumbing Products Group; Wilkins Div.

2.2 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

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

   a. FEBCO.
   b. Watts Industries, Inc.
   c. Zurn Plumbing Products Group.

2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. End Connections: As scheduled.
6. Configuration: Designed for flow direction as required in drawings.
7. Accessories:

   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
   c. All accessories as scheduled and/or detailed on drawings.

B. Double-Check Backflow-Prevention Assemblies:

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

   a. FEBCO.
   b. Ames.
   c. Watts Industries, Inc.
   d. Zurn Plumbing Products Group.

2. Operation: Continuous-pressure applications, unless otherwise indicated.
3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. End Connections: As Scheduled.
6. Configuration: Designed for flow direction as indicated on drawings.
7. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
   b. All accessories as schedule and/or details on drawings.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Honeywell Water Controls.
      c. Watts Industries, Inc.
      d. Zurn Plumbing Products Group.
   2. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
   4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.4 BALANCING VALVES

A. Balancing valves shall be Y-Pattern globe style design and constructed of all metal parts of nonferrous, pressure die cast nonporous Ametal brass copper alloy with EDPM o-ring seals. Each valve shall provide 4 functions:
   1. Precise flow measurement.
   2. Precision flow balancing.
   3. Positive shut-off with no drop seat.

B. Balancing valves shall have four (4) 360° adjustment turns on the handwheel for precise setting with hidden memory to provide a locking tamper-proof balancing setting. Handwheel shall have a digital readout. The handwheel shall have the ability to be installed in any position without affecting performance.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Leonard Valve Company.
DOMESTIC WATER PIPING SPECIALTIES

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless noted otherwise.
2. Body: Bronze for NPS 2" and smaller, cast iron for NPS 2-1/2" and larger.
3. End connections: Threaded for NPS 2" and smaller, flanged for NPS 2-1/2" and larger.
4. Screen: Stainless steel with round perforations unless noted otherwise.
5. Perforation size:

   a. Strainers NPS 2" and smaller: 0.033 inch
   b. Strainers NPS 2-1/2" to NPS 4": 0.062 inch


2.7 HOSE BIBBS

A. Hose Bibbs:

2. Seat: Bronze, replaceable.
3. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
7. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
8. Finish for Service Areas: Rough bronze.
9. Finish for Finished Rooms: Chrome or nickel plated.
11. Include operating key with each operating-key hose bibb.
12. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.8 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

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

A. Ball-Valves Type, Hose End Drain Valves:

1. Standard: MEE SP-110 for standard port, two-piece ball valves.
2. Pressure Rating: 400 psig minimum CWP.
4. Body: Copper Alloy.
5. Ball: Chrome Plated Brass.
8. Inlet: Threaded or Solder Joint.

2.10 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

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

   b. Sioux Chief Manufacturing Company, Inc.
   d. Tyler Pipe.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group.

3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.11 TRAP-SEAL PRIMER VALVES

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

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

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

   a. Sioux Chief Manufacturing Company, Inc.


5. Body: Bronze.

6. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.

7. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.

8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two (2) 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 unless otherwise indicated.

C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

   1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Install Y-pattern strainers for water on supply side of each control valve and pump.

G. Water hammer arresters in first paragraph below are best shown on water risers and details. Specifying number, size, and location here is difficult.

H. Install water hammer arresters in water piping according to PDI-WH 201.

I. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

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

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each reduced-pressure-principle backflow preventer and double-check backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.3 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow of balancing valves.

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

END OF SECTION 221119
SECTION 221124 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Variable Speed Wet-Rotor Inline Circulator Pumps
3. Controls
4. Flexible Connectors

1.2 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and maintenance data.

1.3 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

PART 2 - PRODUCTS

2.1 VARIABLE SPEED WET ROTOR CIRCULATOR PUMPS

A. Available Manufacturers:

1. Grundfos.
2. Engineer Approved Equal.

B. Description: In-Line wet rotor designed pump. Oil lubricated pumps and shaft coupled pump are not acceptable. The pump shall be a standard product. The pump, motor, and variable speed drive shall be an integral product designed and built by the same manufacturer. Pump enclosure shall be marked “Enclosure Type 2.”

C. Pump shall be certified and listed to comply with UL778, UL 60730-1A, and CSA No. 108.

D. Pump shall have the following ratings:

1. Maximum Pressure: 175 PSIG.
2. Media Temperature Range (Min-Max): 14°F - 230°F.
3. Maximum Sound Pressure Level: 43 dBA.
4. Voltage/Phase: 120/1, unless specifically scheduled on drawings.
E. Pump Construction:

1. Housing: 304 Stainless Steel.
2. Impellers: Composite PES 30% GF.
5. Stator Housing: Aluminum.
7. Thrust Bearing: Axial – Carbon Graphite; Radial – Ceramic Alumina Hilox
8. O-Rings: EDPM.
11. 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. Operating Modes: The pump shall have the following control mode and operating modes.

1. AUTOADAPT – 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. FLOWLIMIT - 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. FLOWADAPT – 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. Shall be capable of accepting an optional add-on module for integration into Building Management Systems:

   a. Bacnet
   b. Modbus

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.

2.2 FLEXIBLE CONNECTORS

A. Manufacturers:

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

B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include 125-psig minimum working-pressure rating and ends matching pump connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with HI 1.4.
B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. The pump shaft shall be installed horizontally per manufacturer’s recommendations. The terminal box shall be located as per manufacturer’s recommendations. The system shall be vented out from a higher location form the pump. The required inlet pressure by the pump shall be available at the pump inlet.

E. Install continuous-thread hanger rods and elastomeric hangers of sufficient size Mechanical Vibration to support pump weight. Vibration isolation devices are specified in Division 22 Section "Plumbing Vibration Isolation." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

F. Install immersion-type thermostats in hot-water return piping.

G. Install timers in mechanical room.

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

I. Install piping adjacent to pumps to allow service and maintenance.

J. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."

1. Install flexible connectors adjacent to pumps in suction and discharge piping of in-line centrifugal pumps.

2. Install shutoff valve and strainer on suction side of pumps, and check valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.

3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Conductors and Cables."

M. Interlock pump with water heater burner and time delay relay.
3.2 TESTING

A. The pumps shall be factory performance and hydrostatic tested as a complete unit prior to shipment. The testing shall be done in accordance with ISO 9906 Annex A. No test certificate is required.

3.3 WARRANTY

A. The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture. Warranty shall cover pump, motor and terminal box as a complete unit.

END OF SECTION 221124
SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following soil and waste, sanitary drainage and vent piping inside the building:

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

1.2 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:


1.3 SUBMITTALS

A. Field quality-control inspection and test reports.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS


B. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

   a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Special pipe fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

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

3.2 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

D. Install cast-iron sleeve with waterstop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

E. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if (two) 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.

F. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 VALVE INSTALLATION

A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Backwater valves are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.4 HANGER AND SUPPORT INSTALLATION

A. Delete first paragraph below if not required.

B. Install hangers and supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

D. Maximum spans below were taken from MSS SP-69 for water service and from model plumbing codes. Most restrictive piping and spacing dimensions are shown.

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

F. Support piping and tubing according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

B. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
3.6 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. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction.

1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
2. Prepare reports for tests and required corrective action.

3.7 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following sanitary drainage piping specialties:

1. Cleanouts.
2. Floor Drains/Floor Sinks.
3. Roof flashing assemblies.
5. Grease interceptors.

1.2 SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

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

PART 2 - PRODUCTS

2.1 CLEANOUTS
A. Exposed Cast-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Tyler Pipe.
   d. Watts Drainage Products Inc.
   e. Zurn Plumbing Products Group.

2. Size: Same as connected drainage piping
3. Provide with body, closure, and plug equal to as scheduled on drawings.

B. Cast-Iron Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Tyler Pipe.
   d. Watts Drainage Products Inc.
e. Zurn Plumbing Products Group.

2. Size: Same as connected branch.
3. Type, body, frame, and cover equal to as scheduled on drawings.

2.2 FLOOR DRAINS/FLOOR SINKS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Tyler Pipe.
   d. Watts Drainage Products Inc.
   e. Zurn Plumbing Products Group.

2. Size: Same as connected branch, unless noted otherwise.
3. Type, body, frame, and cover equal to as scheduled on drawings.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Engineering Company; Elmdor/Stoneman Div.
   b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 4.0-lb/sq. ft., thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.


2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

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

   2. Size: Same as connected waste piping [with increaser fitting of size indicated].

B. Deep-Seal Traps:

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

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

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

D. Air-Gap Fittings:

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

E. Sleeve Flashing Device:

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

F. Vent Caps:

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

2.5 GREASE INTERCEPTORS

A. Plastic Grease Interceptors

1. Standard: ASME A112.14.3 (Type C) and CSA B481.1 for intercepting and retaining fats, oils, and greases from food preparation wastewater.
2. Grease interceptor shall be lifetime guaranteed and made of seamless rotationally molded high-density polyethylene with minimum 3/8” uniform wall thickness.
3. Grease interceptor shall be furnished for below grade installation.
4. Grease interceptor shall be furnished with field adjustable riser system, built-in flow control, built-in test caps, and three outlet options.
5. Cover shall be water/gas tight.
6. Capacities and Characteristics:
   a. Flow Rate: 100 GPM.
   b. Grease Capacity: 1,076 lbs.
c. **Cover Load Capacity**: 16,000 lbs.

7. Interceptor shall be provided with lifetime guaranteed sampling port made of seamless rotationally molded high-density polyethylene with minimum 3/8” uniform wall thickness. Port shall be built in accordance with the Water Environment Federation’s “Standard methods for Examination of Water and Wastewater” with sealed top access port and highway rated composite cover and field adjustable risers as required when buried.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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

B. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install floor drains and floor sinks at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated. Block out floor prior to pouring of concrete and then level floor drain after power is set, remove forms and grout hole level.

1. Position floor drains and floor sinks for easy access and maintenance.
2. Set floor drains and floor sinks below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

   a. **Radius, 30 Inches or Less**: Equivalent to 1 percent slope, but not less than 0.25-inch total depression.
   b. **Radius, 30 to 60 Inches**: Equivalent to 1 percent slope.
   c. **Radius, 60 Inches or Larger**: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

G. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

H. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

I. Assemble open drain fittings and install with top of hub 2 inches above floor.

J. Install deep-seal traps on floor drains and other waste outlets, if indicated.

K. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

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

M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

N. Install vent caps on each vent pipe passing through roof.

O. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.
2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.
4. Underground, Buried Installation: Install components in accordance with manufacturer’s instructions and approved product data submittals.
5. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.
3.2 CONNECTIONS

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

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

C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Plumbing Identification."

3.5 PROTECTION

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

END OF SECTION 221319
SECTION 221323 - SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Grease interceptors.

1.3 DEFINITIONS
   A. FRP: Fiberglass-reinforced plastic.
   B. PP: Polypropylene plastic.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of [metal] [and] [plastic] interceptor. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
   B. Shop Drawings: For each type and size of precast concrete interceptor indicated.
      1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS
   A. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
      1. Piping connections. Include size, location, and elevation of each.
      2. Interface with underground structures and utility services.

1.6 FIELD CONDITIONS
   A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
      1. Notify Owner no fewer than seven days in advance of proposed interruption of service.
      2. Do not proceed with interruption of sewer services without Owner's written permission.
PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

A. Precast Concrete Grease Interceptors: Comply with ASTM C 913.
   1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
   2. Structural Design Loads:
      d. Walkway Load: Comply with ASTM C 890, A-03.

3. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.
   a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
   c. Include indented top design with lettering cast into cover, using wording equivalent to GREASE INTERCEPTOR

B. Cast-Iron or Steel Grease Interceptors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Rockford Sanitary Systems, Inc.
      d. Schier Products Company.
      e. Tyler Pipe; a subsidiary of McWane Inc.
      f. WATTS.
      g. Zurn Industries, LLC.
   3. Body Material: Cast iron or steel.
   4. Interior Lining: Corrosion-resistant enamel
   5. Exterior Coating: Corrosion-resistant enamel
   6. Body Dimensions: See plans and schedule

PART 3 - EXECUTION

3.1 EARTHWORK
   A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION
   A. Equipment Mounting:
1. Install grease interceptors on cast-in-place concrete equipment base(s).
2. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

B. Install precast concrete interceptors according to ASTM C 891.
C. Set interceptors level and plumb.
D. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.
E. Set tops of manhole frames and covers flush with finished surface in pavements.
   1. Set tops 3 inches above finish surface elsewhere unless otherwise indicated.
F. Set tops of grating frames and grates flush with finished surface.
G. Set metal interceptors level and plumb.
H. Set tops of metal interceptor covers flush with finished surface in pavements.
   1. Set tops 3 inches above finish surface elsewhere unless otherwise indicated.

3.3 CONNECTIONS
A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION
A. Identification materials and installation are specified in Section 312000 "Earth Moving."
   1. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
   2. Use warning tapes or detectable warning tape over ferrous piping.
   3. Use detectable warning tape over nonferrous piping and over edges of underground structures.
B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Grease interceptors.

3.5 PROTECTION
A. Protect sanitary waste interceptors from damage during construction period.
B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 221323
SECTION 221413 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.

1.4 SUBMITTALS

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

B. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

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


PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
PART 3 - EXECUTION

3.1 EXCAVATION

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

3.2 PIPING APPLICATIONS

A. Select piping applications from this Article. Coordinate with materials specified in Part 2. Edit to suit Project.

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

C. Aboveground storm drainage piping NPS 6 shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

D. Aboveground, storm drainage piping NPS 8 shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

E. Underground storm drainage piping (all sizes) shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gasketed joints.

3.3 PIPING INSTALLATION

A. Storm sewer piping outside the building is specified in Division 33 Section "Storm Utility Drainage Piping."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialities."

D. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

H. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

J. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

K. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results Plumbing."


3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Backwater valve are specified in Division 22 Section "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Division 22 Section "Plumbing Supports, Anchors, and Seals."

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

D. Install hangers for storm drainage piping with horizontal spacing and minimum rod diameters as specified in Division 22 Section “Plumbing Supports, Anchors, and Seals”.

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

F. Support piping according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

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

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

3.8 FIELD QUALITY CONTROL

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

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

5. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221413
SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following storm drainage piping specialties:

1. Cleanouts.
2. Through-penetration firestop assemblies.
3. Roof drains.
4. Miscellaneous storm drainage piping specialties.
5. Flashing materials.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:

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

   c. Tyler Pipe.
   d. Zurn Plumbing Products Group.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material, closure, and plug equal to as specified on drawings.

B. Metal Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company
   c. Tyler Pipe.
   d. Zurn Plumbing Products Group.

2. Standard: ASME A112.36.2M for cleanout.
3. Size: Same as connected branch.
4. Type, body, and cover equal to as scheduled on drawings.

2.2 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

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

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ProSet Systems Inc.

4. Size: Same as connected pipe.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
7. Special Coating: Corrosion resistant on interior of fittings.

2.3 ROOF DRAINS

A. Roof Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Froet.
   b. Engineer Approved Equal.

2. Standard: ASME A112.6.4
3. Pattern: Roof drain.
5. Provide with dome strainer, deck clamp, and outlet as scheduled on drawings.
6. Roof drain shall be provided with a 25-year warranty.

2.4 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

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

B. Downspout Boots:
1. Description: Dura-coated cast iron body downspout boot, to be provided with size and inlet/outlet configuration as scheduled on drawings.

C. Downspout Nozzles:
1. Description: A nickel bronze body, to be provided with inlet size and configuration as scheduled and shown on drawings.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. thickness.

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


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

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

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.
C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install catch basins at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

F. Install through-penetration firestop assemblies in plastic at floor penetrations.

G. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

H. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

I. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

J. Install cast-iron soil pipe downspout boots as detailed on architectural drawings.

K. Install conductor nozzles at exposed bottom of conductors where they spill onto grade, at elevations as shown on architectural drawings.

L. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

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

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.

3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

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

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423
SECTION 221429 – SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes wet-pit-mounted, vertical sump pumps and accessories, inside the building, for building storm drainage systems.

1.2 SUBMITTALS

A. Product Data: For each type and size of sump pump specified. Include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and maintenance data.

1.3 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.

PART 2 - PRODUCTS

2.1 WET-PIT-MOUNTED, VERTICAL SUMP PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Aurora Pump
3. Stancor
4. Zoeller
5. Weil
6. Zurn

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sump pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sump pumps.

1. Pump Arrangement: Simplex
2. Casing: Cast iron, with screened inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced non-clog design; overhung, single suction, keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless-steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.

D. Basin Cover: Cast iron or steel with bituminous coating and strong enough to support pumps, motors, and controls. See Part 2 "Sump Pump Basins" Article for requirements.

E. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

F. Motor: Single speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment" with built-in thermal-overload protection appropriate for motor size and duty.

G. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
   1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
   2. High-Water Alarm: Cover-mounted, mechanical-float-switch alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

2.2 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Flex-Weld, Inc.
   4. Metraflex, Inc.

B. Description: 125-psig minimum working-pressure rating and ends matching pump connection:
   1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to tubing.
   2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

PART 3 - EXECUTION

3.1 CONCRETE

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

3.2 SUMP PUMP INSTALLATION

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

B. Install sump pumps according to applicable requirements in HI 1.4.

C. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

D. Suspend wet-pit-mounted, vertical sump pumps from [basin] [basin and pit] [pit] covers. Make direct connections to storm drainage piping.

E. Set submersible sump pumps on [basin] [basin or pit] [pit] floor. Make direct connections to storm drainage piping.

F. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

G. Construct sump pump pits and connect to drainage piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.

H. Support piping so weight of piping is not supported by pumps.

I. Piping installation requirements are specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

J. Install piping adjacent to sump pumps to allow service and maintenance.

K. Connect storm drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 22 Section "Facility Storm Drainage Piping."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for drainage piping.

L. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

M. Connect wiring according to Division 26 Section "Low-Voltage Electrical Conductors and Cables."

END OF SECTION
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SECTION 223100 - WATER SOFTENERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes commercial water softeners.
   1. Commercial Water Softeners
   2. Chemicals.

1.2 SUBMITTALS

A. Product Data: For each type of water softener and water testing kit indicated.
B. Shop Drawings: Include plans, elevations, sections, details, and connections to piping systems.
   1. Include wiring diagrams.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.
E. Warranty: Special warranty specified in this Section.

1.3 QUALITY

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.

1.4 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of the water softener that fails in materials or workmanship within specified warranty period.
   1. Water Softener, Warranty Period: Five years from date of Substantial Completion.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Salt for Brine Tanks: Furnish same form as and at least [four] times original load, but not less than 200 lb. Deliver on pallets in 40- or 50-lb packages.
   2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

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

2.2 COMMERCIAL WATER SOFTENERS

A. Description: Factory-assembled, pressure-type water softener.

1. Manufacturers:
   b. Marlo MR with MX-11 Skid
   c. Water King, Inc.
   d. Water Soft, Inc.

2. Comply with NSF 61, "Drinking Water System Components—Health Effects."

3. Configuration: Single unit with mineral tank(s) and one brine tank, factory mounted on skids.

4. Mineral Tanks: Steel, electric welded; pressure-vessel quality.

B. The purpose of the water softening system shall be to reduce the hardness to less than 120mg/L. The system shall be a Culligan Hi-Flo3 water softener model HCE-60-1.5 designed to handle a flow rate of 45 gallons per minute at a pressure loss not exceeding 15 psi. The system shall have a softening capacity of not less than 40,000 grains of softening capacity per regeneration when a salt dosage of 12 pounds per tank is used.

C. Softener resin tank shall be 16 inches in diameter. The side-shell height shall be 40 inches, sufficient to allow proper freeboard space above the resin bed depth for adequate expansion of the resin during backwashing. Tanks shall be designed for a working pressure of 100 psi. Each shall be equipped with a removable opening in the top head for media filling purposes. All tanks shall be of Culligan Tripl-Hull construction which consists of a 20 mil thick vinyl bag liner hermetically sealed within the steel tank to protect against internal corrosion. The tank exterior shall be protected by a molded plastic jacket for corrosion resistance. It shall also act as an insulator to minimize condensation on the surface of the tank. Twenty-inch tanks shall have the 20 mil thick vinyl bag liner on the interior and a blasted, primed and gloss epoxy-coated exterior.

D. Each softener tank shall be equipped with a soft water collector and backwash water distributor consisting of a plastic riser pipe with a fine-slotted plastic strainer attached to the bottom of the pipe, covered with a minimum of 3 inches of under-bed sand to ensure even distribution of water. Each softener tank will be equipped with an upper distributor that distributes water laterally to ensure maximum water softening capacity.
E. Each softener tank shall be provided with 2 cubic feet of Cullex resin having a minimum exchange capacity of 30,000 grains per cubic foot when regenerated with 15 pounds of salt. The media shall be solid, of the proper particle size (not more than 4% through 40 mesh U.S. standard screens, wet screening) and shall contain no agglomerates, shells, plates, or other shapes that might interfere with the normal function of the water softener. The exchange capacity shall be not less than 27,000 grains per cubic foot when regenerated with 15 pounds of salt. All resin shall be manufactured to comply with the food additive regulation, Paragraph 121-1148 of the Food and Drug Administration.

F. A combination salt storage and brine tank, measuring 18 inches in diameter by 38 inches tall, with cover, shall be provided. The tank shall be molded of corrosion-proof, high-density polyethylene.

G. The brine tank shall be equipped with an elevated salt plate for brine collection, and a chamber to house a brine valve assembly. The brine valve shall automatically open to admit brine to the resin tank during reduction and close automatically to prevent introduction of air into the resin tank. During refill, the brine valve shall regulate the flow of soft water into the brine tank, working with the time refill feature of the softener control valve; together these components shall admit the correct volume of water to the brine tank in accordance with the salt dosage settings on the control valve. The brine valve shall include a float-operated safety shut-off valve, as a back-up to the time refill on the control, to prevent brine tank overflow.

H. The main control valve on all models shall be of the 4-position motor-driven piston-type, to positively locate the internal valve piston to route the flow of water through the softener during service, backwash, brine draw/brine rinse, and fast rinse/brine refill. The valve body shall be molded of phenylene-oxide thermoplastic to resist attack by substances found in natural water supplies.

I. The valve shall contain fixed and self-adjusting flow controls to control water flow through the valve during backwash, brine and slow rinse, and fast rinse, when water pressure is between 30 and 100 psig. The internal piston and seal assembly will be of modular cartridge design for ease of replacement and service. The control shall be fully tested before shipment and shall be made by the same manufacturer as the tank.

J. Unit shall be equipped with inlet and outlet Flo-Pak valves with a diaphragm valve of exclusive cartridge design, with 1-1/2 inch NPT connections. Flo-Pak valves shall control water flow through the softener during the service cycle to permit high flow rates with minimum pressure drop. The control valve shall control water flow through the softener during regeneration only.

K. Regeneration frequency shall be controlled by a 7-day calendar clock which permits regeneration at any time of day or night, on any day or every day of the week. The timer shall permit adjustment of backwash time and fast rinse/refill time. An extra recharge lever shall be provided to permit manual regeneration at any time. The timer control shall be UL listed.

L. An Aqua sensor control shall be provided with the system. It shall consist of a probe that is inserted into the resin bed, and a solid-state amplifier circuit board in the timer housing.

M. The probe shall sense the need for regeneration based on differential water hardness readings and signal the circuit board to initiate regeneration immediately. The system shall
be compensated for variations in water hardness and temperature and shall require no field adjustments when operated within the softeners normal temperature range.

N. An Automatic Reset Water Meter shall be installed in the outlet (service) pipe of the softener. The meter shall initiate regeneration after a pre-set number of gallons have flowed through the meter.

O. Complete instruction for the installation and operation of the softening system shall be provided in booklet form. All component parts shall be easily identified, in exploded views, by individual part numbers.

P. All major components, such as tanks, control valves and internals, shall be designed and assembled by a single source for optimum compatibility. The system shall carry a one-year warranty on workmanship and materials. The media tank shall carry a 12-year warranty against internal corrosion.

Q. Components

1. Controls: Fully automatic; factory mounted on unit and factory wired.
   
   a. Adjustable duration of various regeneration steps.
   b. Push-button start and complete manual operation.
   c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
   d. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.
   e. Pointer on pilot-control valve shall indicate cycle of operation.
   f. Means of manual operation of pilot-control valve if power fails.
   g. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

      1) Slow opening and closing, non-slam operation.
      2) Diaphragm guiding on full perimeter from fully open to fully closed.
      3) Isolated dissimilar metals within valve.
      4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
      5) Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
      6) Sampling cocks for soft water.
      7) Special tools are not required for service.

   h. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.

      1) Demand-Initiated Control: Equip single mineral-tank units with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons.
Design so head automatically resets to preset total in gallons for next service run.

2) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tank. Set to repeat with other tank. Include electrical lockout to prevent simultaneous regeneration of both tanks.

2. Brine Tank: Combination measuring and wet-salt storing system.
   a. Tank and Cover Material: Fiberglass, 3/16-inch-thick; or molded PE, 3/8 inch thick.
   b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   c. Size: Large enough for at least four regenerations at full salting.

3. Factory-Installed Accessories:
   a. Piping, valves, tubing, and drains.
   b. Sampling cocks.
   c. Main-operating-valve position indicators.
   d. Water meters.

2.3 CHEMICALS

A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
   1. Exchange Capacity: 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.

B. Salt for Brine Tanks: High-purity sodium chloride; free of dirt and foreign material. Rock and granulated forms are not acceptable.
   1. Form: Processed, food-grade salt pellets

2.4 WATER TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases of dimensions indicated for commercial water softeners. Refer to Division 22 Section "Common Work Results for Plumbing."
3.2 WATER SOFTENER INSTALLATION

A. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer’s recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.3 CONNECTIONS

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

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

C. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

D. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.

   1. Metal general-duty valves are specified in Division 22 Section "Plumbing Valves."
   2. Plastic valves are specified in Division 22 Section "Domestic Water Piping."
   3. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

E. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Division 22 Section "Meters and Gauges for Plumbing Piping."

   1. Exception: Water softeners with factory-installed pressure gages at locations indicated.
   2. Exception: Household water softeners.
   3. Exception: Water softeners in hot-water service.

F. Install valved bypass water piping around water softeners.

   1. Metal general-duty valves are specified in Division 22 Section "Plumbing Valves."
   2. Plastic valves are specified in Division 22 Section "Domestic Water Piping."
   3. Water piping is specified in Division 22 Section "Domestic Water Piping."

G. Install drains as indirect wastes to spill into open drains or over floor drains.
H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, 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 unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

3.5 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.

B. Add water to brine tanks and fill with salt.

1. Commercial Water Softeners: Plain salt pellets

C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:

2. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
4. ASTM D 1126, "Test Method for Hardness in Water."
5. ASTM D 1129, "Terminology Relating to Water."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water softeners. Refer to Division 01 Section "Demonstration and Training."
END OF SECTION 223100
SECTION 223500 - DOMESTIC-WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Indirect, heating fluid in coil, domestic water heaters.
   2. Plate, domestic water heat exchangers.
   3. Domestic-water, heat-exchanger accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heat exchanger indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:
   1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for domestic-water heat exchangers, 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. Product Certificates: For each type of domestic-water heat exchanger, from manufacturer.

   1. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.
1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic-water heat exchangers to include in emergency, operation, and maintenance manuals.

1.6 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. Compliance with ASHRAE/IES 90.1 is required by LEED 2009, LEED v4, IGCC, ASHRAE 189.1, and Green Globes and may be required even when they do not apply.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G/NSF 372.

1.7 WARRANTY

A. Standard Warranty: Indirect Water Heaters shall carry a limited lifetime warranty against tank failure resulting from defects in materials or workmanship.

PART 2 - PRODUCTS

2.1 INDIRECT, HEATING FLUID IN COIL, DOMESTIC WATER HEATERS

A. Stainless Steel Tank, Indirect Domestic Water Heaters:

1. Description: Packaged assembly of tank, heat-exchanger coils, controls, and specialties for heating domestic water with heating hot water in 316L stainless steel coils.


   a. The coil and interior of the tank shall be subjected to a passivation process designed to inhibit corrosion by cleaning the coil and tank surfaces and washing away iron that was exposed during the manufacturing process.

   b. Tank shall be furnished with two 1” NPT connections for heating hot water supply and return piping.

   c. Tank shall be furnished with 1-1/2” NPT connections for domestic water inlets and outlets.

   d. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls with 2” thick, high density, CFC/HCFC free polyurethane foam insulation to exceed ASHRAE 90.1.

3. Heat-Exchanger Coils: Stainless-steel, helix-wound coils for heating fluid. Include pressure rating equal to or greater than heating-fluid supply pressure.
4. Temperature Control: Adjustable thermostat that operates control valve and is capable of maintaining outlet-water temperature within 4 deg F of setting.
5. Safety Control: Automatic, high-temperature-limit cutoff device or system.
6. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
7. Retain one of first two subparagraphs below. Retain first subparagraph for heating hot-water units or second subparagraph for steam units.
8. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, pumps, and piping.

2.2 PLATE, DOMESTIC-WATER HEAT EXCHANGERS

A. Frame-and-Plate, Domestic-Water Heat Exchangers:
   1. Description: Assembly of nonfixed-position, heat-exchanger plates, with frame, for using heating hot water to heat domestic water.
   2. Working-Pressure Rating: 150 psig minimum.
   3. Frame:
      b. Fixed, Frame Plate; Pressure Plate; Support Column; and Nuts and Bolts: Carbon steel.

4. Channel Plates:
   a. Verify availability of selected models if vented, double-wall units in first subparagraph below are required.
   b. Material: Stainless steel.
   c. Plate Thickness: Not less than 0.024 inch.
   d. Gasket Material: Butyl or acrylonitrile-butadiene rubber, suitable for potable water.

5. Connections: Type L Copper, suitable for potable water.
   a. NPS 2 and Smaller: Threaded.
   b. NPS 2-1/2 and Larger: Flanged.

6. Protective Shroud: Steel, covering channel plates.
7. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire heat exchanger except connections.

B. Capacity and Characteristics:
   1. Refer to On-Drawing Schedule.
2.3 DOMESTIC-WATER, HEAT-EXCHANGER ACCESSORIES

A. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

B. Heat-Trap Fittings: ASHRAE 90.2.

C. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than heat-exchanger working-pressure rating. Select relief valves with sensing element that extends into storage tank.

D. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than heat-exchanger working-pressure rating.

E. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heat exchangers specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER, HEAT-EXCHANGER INSTALLATION


1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Anchor heat exchangers to substrate.
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.

1. Install shutoff valves on domestic-water-supply piping to heat exchangers and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "Plumbing Valves."

2. Install shutoff valves on heating hot-water piping to heat exchangers. Comply with requirements for shutoff valves specified in Section 230523 "HVAC Valves."

C. Install temperature and pressure relief valves in top portion of storage-tank shells of domestic-water heat exchangers with domestic-water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install combination temperature-and-pressure relief valves in water piping for domestic-water heat exchangers without storage. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heat exchangers that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Install thermometer on each domestic-water, heat-exchanger, inlet and outlet piping, and install thermometer on each domestic-water, heat-exchanger, heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 220519 "Meters and Gauges for Plumbing Piping."

G. Install pressure gages on domestic-water, heat-exchanger, heating-fluid piping. Comply with requirements for pressure gages specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Fill domestic-water heat exchangers with water.

I. Charge domestic-water compression tanks with air.

3.2 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.
3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Plumbing Identification."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

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.

B. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heat exchangers.

END OF SECTION 223500
SECTION 224000 - PLUMBING FIXTURES AND ACCESSORIES

PART 1 -GENERAL

1.1 SUMMARY

A. Section includes the following plumbing fixtures and related components:

1. Faucets.
2. Flushometers.
3. Toilet Seats.
4. Fixture Supports.
6. Disposers.
8. Urinals.
9. Lavatories.
11. Individual Showers.
13. Service Sinks.
15. Drains.

1.2 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1, Section 01300, and as follows:

1. Submit catalog data and descriptive literature, as applicable, for all equipment, fixtures, and specialty items in accordance with the Conditions of the Contract and obtain approval of materials before delivery to job site.
2. Shop drawings shall be coordinated with equipment supplied by other Contractors and the Owner.
3. Submit a bound copy of all approved shop drawings, together with complete parts lists and operating and maintenance instructions for all equipment furnished under this Section.

1.3 GUARANTEE

A. The contractor guarantees all plumbing work against any defects due to faulty workmanship or material and that all piping is free from foreign material, obstructions, holes or breaks of any nature.

B. The contractor guarantees the proper circulation and/or drainage of fluid in each piping system.

C. Upon written notice from the Architect or Owner, the contractor shall promptly remedy, without cost to the Owner, any defects occurring within a period of one (1) year from the date of final acceptance.
PART 2 - EQUIPMENT

2.1 CLEANOUTS

A. Cleanouts shall be per plumbing fixture schedule, or per Division 22 section “Sanitary Waste Piping Specialties” and section “Storm Drainage Piping Specialties”.

2.2 DRAINS

A. Drains shall be per plumbing fixture schedule, or per Division 22 section “Sanitary Waste Piping Specialties” and section “Storm Drainage Piping Specialties”.

2.3 FLASHING

A. Contractor shall flash around each vent pipe extending through roof, with 6 lbs. sheet lead. Flashing shall be installed 10 inches in all directions from pipe underneath roofing material and joined with wiped joint to piece of 6 lb. lead soil pipe, carried up, over and turned down into the top of pipe so as to form a permanent watertight joint, and to permit expansion.

B. All lead flashing shall be entirely painted with a good coat of black Asphaltum before installation.

C. Coordinate installation with roofing contractor.

2.4 LEAD SAFE PANS

A. Contractor shall furnish and install for all roof drains, and all clean-out covers and floor drains in floors above grade a 36"x36" 6 lb. sheet lead pan. All surfaces of pans shall be painted with a good coat of black Asphaltum before installation. Lead safe pans shall be watertight.

B. Coordinate roof drain installation with roofing contractor.

2.5 PLUMBING SPECIALTIES

A. Refer to the on-drawing plumbing fixture schedule which govern for models, or where not shown, refer to specifications below.

B. All plumbing specialties shall be furnished and installed per manufacturer's requirements. All work and material required to rough-in, connect-up and install specialties items shall be provided as required for proper operation. Items are specified by manufacturer's numbers as to the type and quality required.

C. Provide fixtures as indicated in the on-drawing plumbing fixture schedule or herein.

D. TP-Trap Primer: Sloan No. F-72-A1 trap primer assembly, installed in conjunction with Royal No. 113-3 flush valve, with 3/8" tubing and fittings to wall connection. Contractor to provide and install piping between wall fitting and drain trap.

E. GPR-Gas Pressure Regulators: Pressure regulating valves shall be of size and capacities indicated on the drawings. Pressure regulators shall be provided with full flow relief vented
outside of the building. Gas pressure regulators shall be provided with inlet and outlet pressure gauges. Regulators shall be Rockwell, Fisher, or approved equal.

F. PRV Water Pressure Reducing Valves: Pressure reducing valves shall be factory set for required pressure and shall be provided with stainless steel or nickel alloy renewable seats, stainless steel strainer screens, high temperature diaphragms, and shall be rated at a minimum of 250 psig-wwp.

G. Flexible Connections: Flexonics Series 400, or approved equal, braided flexible hose with screwed ends, seamless stainless steel bellows and stainless steel woven braid. Hose shall be of the length and pressure ratings, etc., as required for services and conditions encountered.

H. Thermal Expansion Absorber Tank: Amtrol Model AST Extrol or approved equal for potable water heaters, shall be of the positive fixed diaphragm type, factory pre-charged and field adjustable, with heavy duty Butyl diaphragm rigid polypropylene liner, and rust resistant baked epoxy finish outer shell, complete with NPT system connection and stainless steel air charge valve to facilitate on-site charging. Size and capacity as indicated on the drawings.

 Tank shall be installed on the cold water side of the water heater, connected between heater and backflow preventer, and charged with air pressure as required by the system operating pressure. Tank shall be ASME constructed and rated for not less than 125 psi working pressure and 200 degree working temperature.

2.6 PLUMBING FIXTURES

A. Furnish plumbing fixtures as indicated on the on-drawing plumbing fixture schedule.

B. All plumbing fixtures, equipment and related accessories shall be furnished and installed in a neat, finished and uniform manner. All work and material required to rough-in, connect up and install supply, drain, waste, soil and vent piping shall be provided as required for proper operation. This shall include plumbing fixtures, equipment and accessories and includes items furnished under other sections or furnished by the Owner. Fixtures, equipment and accessories are specified by manufacturer’s numbers as to the type and quality required. (NOTE: The architect may reject any fixture, equipment item or accessory which, in his opinion is not of the quality or type specified.). Specified manufacturers and approved equal manufacturers are as follows.

C. All vitreous china and enameled cast iron fixtures shall be white in color, acid resisting, without blemishes and the best of their respective kind.

D. All stainless steel fixtures shall be 18 gauge, type 302 (18-8) nickel bearing stainless steel, with brushed satin finish and sound deadening undercoat.

E. Plumbing trim utilized shall be provided with renewable seats and replaceable internal working components.

F. Each water closet shall be provided with a seat, seats shall be white, elongated open front, with combination self-sustaining check hinges.

G. Unless otherwise specified, each lavatory shall be provided with: McGuire LFBV02 quarter-turn angle stops and M65 3/8” x 12” (min) flexible risers; McGuire 8902 adjustable, semi cast
plumbing fixtures and accessories

brass P-trap (1¼" inlet, 1½" outlet) with ground swivel joint, cleanout plug, slip inlet and 17 gauge 1½" trap arm. Provide McGuire 15BWC loose key straight stop supplies for wheelchair lavatories.

H. Unless otherwise specified, each sink shall be provided with: McGuire LF8V02 quarter-turn angle stops and M66 3/8" x 15"(min) flexible risers; McGuire 151 basket strainer, 1½" x 4" 17 gauge tailpiece with brass locking and coupling nuts, McGuire 8912 adjustable, semi cast brass P-trap (1½") with ground swivel joint, cleanout plug, slip inlet and 17 gauge 1½" trap arm. Provide additional strainers, tailpieces and continuous waste pieces for multiple compartment sinks as required.

I. All fixtures shall be substantially supported in an approved manner. Furnish and install adjustable carriers with legs, floor bases, bearing plates, support arms or rods as required for all wall hung fixtures. Anchor carriers to floor and brace to wall construction for substantial support. Carriers shall be required to fit fixtures furnished. Verify available space for carriers and provide appropriate carrier to fit space and building construction. Install all supports before walls are finished. The Contractor shall be responsible for a period of one year following final acceptance of the building, for the loosening of any plumbing fixture and any subsequent damage to the building caused by the fixture or as a result of leaks in piping, and shall promptly make repairs to the building, shall replace or repair fixture carriers as deemed necessary by the Architect at no additional cost to the contract.

J. All fixtures shall be set true and level. Install all fixtures in accordance with manufacturer’s requirements and at recommended heights unless otherwise indicated.

K. Fixtures that are wall hung or butt a wall shall have adjacent edges and surfaces factory ground true and square.

L. All spaces between fixtures and finished surfaces shall be caulked and pointed square with an approved white silicone sealant resulting in a neat and smooth appearance.

M. All exposed fixture trim shall be polished chrome plated brass.

N. The contractor shall be responsible for the protection and cleanliness of all fixtures, equipment and accessories.

O. Set all countertop fixtures with caulking compound and seal edge of rim with an approved white silicone sealant for a neat, smooth appearance.

P. All precast receptors and basins shall be of standard color and set level in a bed of cement mortar per manufacturers requirements.

Q. All water supply fittings shall close with pressure and have model trim.

R. Refer to the on-drawing plumbing fixture schedule for models, accessories, etc. They govern for bidding.

S. The following fixture and equipment list specifies the basic fixture or item, each of which shall be provided with applicable accessories for its proper operation.

1. Refer to on-drawing fixture schedule.
PART 3 - EXECUTION

3.1 FIXTURE BRANCH PIPING

A. Size piping as indicated on drawings and diagrams but not smaller than indicated in the "Branch Fixture Schedule" below.

1. Connection to individual plumbing fixtures shall be as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Waste</th>
<th>Vent</th>
<th>Cold</th>
<th>Hot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinal</td>
<td>2&quot;</td>
<td>1 ½&quot;</td>
<td>1&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Water Closet</td>
<td>4&quot;</td>
<td>2&quot;</td>
<td>1 ¼&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Lavatory</td>
<td>2&quot;</td>
<td>1 ¾&quot;</td>
<td>½&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Drinking Fountain</td>
<td>2&quot;</td>
<td>1 ¼&quot;</td>
<td>½&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Janitor Basin</td>
<td>3&quot;</td>
<td>1 ½&quot;</td>
<td>½&quot;</td>
<td>½&quot;</td>
</tr>
<tr>
<td>Shower</td>
<td>2&quot;</td>
<td>1 ½&quot;</td>
<td>½&quot;</td>
<td>½&quot;</td>
</tr>
<tr>
<td>Sink</td>
<td>2&quot;</td>
<td>1 ½&quot;</td>
<td>½&quot;</td>
<td>½&quot;</td>
</tr>
</tbody>
</table>

B. Provide air chambers at all locations where supply pipes terminate. All air chambers shall be full size of supply piping and 15" long except for flush valves shall be 18" long.

C. All exposed connections and fittings shall be chrome plated brass. All supplies, stops, escutcheons, tailpieces, traps and trap arms within cabinets shall be considered exposed.

D. Provide chrome plated cast brass set-screw escutcheons for all exposed fixture supply and waste piping.

E. All fixture supply and waste piping through wall shall be rigidly supported. Supports in contact with copper piping shall be copper plated or fire-retardant plastic.

3.2 SHOCK ABSORBERS

A. Shock absorbers: Furnish and install sealed bellows shock absorbers in the water supply to each bank of plumbing fixtures in main toilet rooms as shown on drawings and in make-up water connections where solenoid valves are installed as shown on drawings. Shock absorbers shall be sized and rated for number of fixtures in each bank in accordance with the Plumbing and Drainage Institute (PDI) Standard PDI-WH201.

B. Manufacturers:

1. Wade: Wade Series W "Shokstop"
2. Zurn
3. Josam

END OF SECTION 224000
SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Combination units.
   2. Supplemental equipment.
   3. Water-tempering equipment.

1.3 DEFINITIONS
A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
C. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS
A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.
B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE
B. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 COMBINATION UNITS

A. Standard, Plumbed Emergency Shower with Eyewash Combination Units:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Safety.
   b. Bradley Corporation.
   c. Guardian Equipment Co.
   d. Haws Corporation.

2. Piping:
   a. Material: Chrome-plated brass or stainless steel
   b. Unit Supply: NPS 1-1/2
   c. Unit Drain: Outlet at back or side near bottom.

3. Shower:
   a. Capacity: Not less than 20 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Pull rod
   d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel
   e. Mounting: Pedestal.

4. Eyewash Unit:
   a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
   d. Spray-Head Assembly: Two receptor-mounted spray heads.
   e. Receptor: [Chrome-plated brass or stainless-steel] [Plastic] bowl.
   f. Mounting: Attached shower pedestal.

2.2 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Safety.
   b. Bradley Corporation.
   c. Guardian Equipment Co.
   d. Haws Corporation.
   e. Leonard Valve Company.
2. Description: Factory-fabricated equipment with thermostatic mixing valve.
   a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
   b. Supply Connections: For hot and cold water.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523. "Plumbing Valves".

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

G. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."
3.3 CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

C. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
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 unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.
END OF SECTION 224500
SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide items, articles, materials, operation and methods required by drawings and specifications including labor, equipment, supplies and incidentals necessary for completion of work in Division 23 – Heating Ventilating and Air Conditioning.


1.2 RELATED DOCUMENTS

A. The General Provisions described herein, together with the conditions of contract, and the General Requirements of Division 1, apply to the work in Division 23 – Heating Ventilating and Air Conditioning.

B. This Section is hereby made a part of all other sections of Division 23 – Heating Ventilating and Air Conditioning, as if repeated in each.

1.3 QUALITY ASSURANCE

A. All permits and licenses that are required by governing authorities for the performance of shall be procured and paid for by the Contractor.

B. All work shall be performed in compliance with all applicable and governing safety regulations including the regulations of the Occupational and Safety Health Act. All safety lights, signs and guards required for performance of work shall be provided by the Contractor.

C. All work shall conform to the requirements of all applicable codes, ordinances and regulations including the rules and regulations of the National Electrical Code, the National Fire Protection Association, the International Mechanical Code, OSHA and all State and Local laws, codes and ordinances.

D. Laws, codes, ordinances and regulations shall take precedent excepting only where the work called for by the drawings and specifications exceeds by quality and quantity.

E. Fixtures, appliances, equipment and materials which are subject to Underwriter's Laboratory tests shall bear such approval.

F. Mechanical and electrical designs are based on the requirements for the specified manufacturers listed on the equipment schedules. Conduit, disconnects, motor starters, breakers, fuses and wire sizes are selected on basis of scheduled equipment. Increased current requirements necessitating larger wire, breakers, switches, etc., to accommodate any alternate or substitute manufacturer's equipment, other than as shown on drawings shall be provided without any increase in contract price by contractor furnishing the equipment.

G. Manufacturers, where specifically called for, must provide factory tests, unit installation observations, unit start-up and tests, etc., as specified, and submit signed reports to the Engineer upon completion of these services. Subletting of these services will not be permitted. Shop
drawing submittals shall be accompanied with a letter of certification by the manufacturer that the specified services shall be provided. Failure to do so shall be cause to reject the shop drawing submittals.

H. The contract drawings are in part schematic and intended to convey the scope of work and indicate the general layout, design and arrangement. The Contractor shall follow these drawings in the layout of his work and shall consult general construction drawings, electrical drawings and all other drawings for this project, and shall verify all existing site conditions to determine all conditions affecting the work shown or specified. The contract drawings are not to be scaled and the Contractor shall verify spaces in which the work is to be installed.

I. Follow drawings in laying out work, check drawings of other trades to verify spaces in which work will be installed, and maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, Engineer shall be notified before proceeding with installation.

J. Work in cooperation with one another to fit piping and ductwork into the structure as job conditions may demand. All final decision as to right of way and run of pipe, ducts, etc. to be made by Engineer or his representative.

K. All work shall be performed by trained mechanics of a particular trade involved and done in neat and workmanlike manner as approved by "Engineer".

1. Work shall be performed in cooperation with other trades and scheduled to allow timely and efficient completion of project.
2. Furnish other trades advance information on locations and sizes of frames, boxes, sleeves and openings needed for work, and also furnish information and shop drawings necessary to permit other trades affected to install their work properly without delay.
3. Where there is evidence that work of one trade will interfere with work of other trades, all trades shall assist in working out space conditions to make satisfactory adjustments.

L. Work installed before coordinating with other trades causing interference with work of such other trades shall be changed to correct such condition without increase in contract price and as directed by Engineer.

M. Where specific details and dimensions are not shown on the drawings, the Contractor shall take measurements and make layouts for the proper installation of the work and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications, it shall be assumed, by the signing of the Contract, that the higher cost (if any difference in costs) is included in the contract price, and the Contractor shall perform the work in accordance with the drawings or with the specifications, as determined and approved by the Engineer.

N. The Contractor shall be responsible for a scheduled sequence in performing the work so that it will not interfere with the Owner's operation in the existing building. Before any work is started, the Contractor shall consult with the Engineer and Owner and arrange a satisfactory schedule.

1. Make temporary alterations as required to execute work so that all operations and services in the existing building are maintained with the minimum possible interruption.
2. Temporary shut-downs shall be segregated and shall be of the shortest possible duration. All facilities shall be kept in continuous operation unless specific permission to the contrary is granted by Owner.
O. Definitions:

1. "Piping" includes, in addition to pipe, all fittings, valves, sleeves, hangers, and other supports and accessories related to such piping.
2. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction, or in crawl spaces.
3. "Exposed" means not installed underground or "concealed" as defined above.
4. The words "furnish and install", "provide", "furnish", "install", or equivalent words are used or are understood, to mean the Contractor shall furnish and completely install the system, service, equipment, or material named, together with other associated devices, equipment, material, wiring, piping, etc. as required for a complete operating installation, and conforming to the manufacturer's standards and recommendations.
5. It is the intent of these specifications and drawings to call for finished work, tested and ready for operation.
6. All apparatus, appliances, materials or work not shown on drawings, but mentioned in specifications, or vice versa, and/or all incidental accessories necessary to make work complete and ready for operation, even though not specified or shown on drawings, shall be furnished and installed without increase in contract price.
7. Should there be discrepancies or questions of intent, refer matter to Engineer in writing for decision before ordering any equipment or materials or before starting any related work.

1.4 SHOP DRAWINGS AND SAMPLES

A. Shop drawings, project data and samples furnished by the Contractor shall illustrate materials, equipment or workmanship, and establish standards by which the work will be judged.

B. Shop Drawings and Samples shall be submitted to the Engineer by a letter of transmittal. The party making the submission shall be named on Shop Drawing/Sample and also in the letter of transmittal.

C. When Shop Drawing submissions are in the form of loose pages (8½" x 11") they shall be submitted in sets assembled in portfolio binders showing on the covers or first page inside, a complete list of contents. A minimum of 7 sets of each submission are required, however, additional copies may be requested.

D. When Shop Drawing submissions are in the form of portable document format (PDF), they shall be transmitted via email to the contact information provided during the pre-construction conference. Each submittal transmitted in PDF format shall include only one specification section. Multiple specification section submittals combined into one singular PDF file will not be accepted. The cover page of the submittal shall include all necessary information for proper identification of project, submittal, and date, and shall include a blank area, minimum 4-1/4" by 5-1/2" in size, for placement of the engineer’s review stamp. The email transmittal and PDF file naming shall be compliant with the following guidelines:

1. Email submittals to be addressed to: TBD, as instructed during pre-construction conference.
2. Email subject line shall include the following information, in order of listed below and separated by dashes:
   a. "SUBMITTAL"
   b. Project Number (as listed in titleblock and specifications).
   c. Specification Section Number
   d. Specification Title
The PDF file for the actual submittal shall be compliant with the following guidelines:

3. The PDF file for the actual submittal shall be compliant with the following guidelines:
   a. Project Number (as listed in titleblock and specifications).
   b. Specification Section Number
   c. Sequence Number (separated from section number by a 'dot'). In the case of a resubmittal, the sequence number shall remain the same as the previously submitted file, and shall be
   d. Specification Title
   e. “FOR REVIEW”
   f. Example: “16076.1-230523.01-HVAC Valves-FOR REVIEW.pdf”.

4. Failure to follow email transmittal or document naming guidelines will result in an automatic rejection of submittal.

E. The Contractor shall review, stamp with his approval and submit, with reasonable promptness and in orderly sequence so as to cause no delay in the work or in the work of any other contractor, all Shop Drawings and Samples required by the Contract Documents or subsequently by the Engineer as modifications. Shop Drawings and Samples shall be properly identified as specified or as the Architect/Engineer may require. At the time of submission, The Contractor shall inform the Architect/Engineer in writing of any deviation in the Shop Drawings or Samples from the requirements of the Contract Documents.

F. Except in the case of brochures, catalogue cuts and the like, shop drawings shall be in the form of a reproducible print(s) (sepia). In every case, the submittal shall consist of one sepia of each shop drawing and two (2) black line prints of the same. Each print shall be made from the original shop drawing tracing. The transparency shall be capable of producing clean, clear black and white prints.

G. Contractor shall stamp each sepia and black line print (shop drawing) the same. He shall also stamp each brochure, sample and the like. Special Note: Every page with project information shall be stamped. In every instance, the document shall be reviewed by the Contractor and shall also be signed by the Contractor indicating that the document has been reviewed, and that it is approved by the Contractor. The submittals will not be reviewed without the Contractor's approval stamp and signature.

H. The Contractor's approval stamp and signature shall signify that the Contractor has checked the submittals. Any submittals which have not been checked shall be returned to the Contractor for checking, approval stamp, signature, and resubmittal for compliance with the contract documents. After review of the submittals they will be returned to the Contractor with one of the following remarks checked:

1. No Exceptions Taken SUBJECT TO CONTRACT DOCUMENTS.
2. Note Corrections SUBJECT TO CONTRACT DOCUMENTS, RESUBMISSION NOT REQUIRED.
3. Revise and Resubmit REVISE, RESUBMISSION REQUIRED.
4. Rejected NOT APPROVED.

I. Upon receipt of exhibits submitted and marked for resubmittal the Contractor shall cause the marked corrections, and corrections that may be contained in the Architect/Engineer transmittal letter to be made on each submittal. All such corrections shall be circled, numbered, and dated.
to permit prompt reviewing upon resubmittal to the Architect/Engineer. Upon receipt of each submittal now marked:

J. The Contractor shall cause submittals to be distributed to the respective contractors and suppliers as is necessary for proper performance of work.

K. At the time of submission, the Contractor shall inform the Engineer in writing of any deviation in the exhibits submitted from the requirements of the Contract.

L. The Engineer will review exhibits submitted with reasonable promptness so as to cause no delay, but only for conformance with the design concept of the Project and with the information given in the Contract. The Engineer's review of a separate item shall not indicate review of an assembly in which the item functions. The Engineer's review is not intended to indicate approval of dimensions or quantities.

M. Contractor shall make any corrections required by the Engineer and shall resubmit the required number of submittals until further resubmittals are no longer required.

N. Engineer's review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract unless the Contractor has the Engineer's approval in writing of such deviation at the time of submission and the Owner's Representative has given written notice to the specific deviation; nor shall the Engineer's review relieve the Contractor from responsibility for errors or omissions in the submitted exhibits.

O. No portion of the work requiring a submittal shall be commenced until the Engineer has reviewed the submission. All such portions of the work shall be in accordance with reviewed submittals.

1.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to the requirements specified in Division 1, the Contractor at the project's completion shall submit a complete system operating and maintenance manual. O&M manual shall be organized into systems and shall contain the manufacturer's complete detailed operating and maintenance instructions with equipment data for each piece of installed equipment furnished under this project. Manual at a minimum shall include the following:

B. Manual shall be composed of typed instructions sheets with large drawing sheets (not reduced) folded in with reinforced margin, shall have a post binder system so that sheets can be easily substituted, and shall have a hard cover.

C. Include in O&M manuals Manufacturers written maintenance instruction for each different piece of equipment provided and installed on this project.

D. Include spare parts list for each major piece of equipment furnished for the project including but not limited to controls, boilers and accessories.

E. Provide a comprehensive list of maintenance procedures for preventative maintenance and troubleshooting; disassembly, repair and reassemble; aligning and adjusting instructions.
2.1 GENERAL

A. All materials and equipment shall be new and shall bear manufacturer’s name, model number and other identification marking.

B. All materials and equipment shall be standard product of manufacturer regularly engaged in production of required type of material or equipment for at least 5 years (unless specifically exempted by Engineer) and shall be manufacturer’s latest design having published properties.

2.2 FIRESTOPPING

A. Firestopping is defined herein as the process of furnishing and installing a material, or combination of materials, in various constructions to maintain an effective barrier against the spread of flame, smoke, and gasses and to retain the integrity of time-rated construction. It shall be used in specific locations as specified hereinafter.

1. Piping penetrations through floor slab and through time-rated partitions of fire walls;
2. Opening between floor slabs and curtain walls, including inside hollow curtain walls at the floor slab;
3. Penetrations of vertical service shafts;
4. Openings and penetrations in enclosures with time-rated fire doors;
5. Other locations where specifically shown on drawings or where specified in other sections of these specifications;
6. Openings in non-time-rated construction shall be closed with a compacted fill of ¾ lb. density fiberglass and then sealed gas tight.

B. Material of firestopping shall be asbestos free and capable of maintaining an effective barrier against flame, smoke and gases in compliance with the requirements of ASTM E 814, UL NO. 1479. Fire-stopping material shall be manufactured by 3M barrier products. Products shall be capable of providing a cold smoke and water seal. When exposed to temperatures exceeding 250°F these products shall rapidly expand up to ten times the original volume.

C. Installation of fire stopping shall be in accordance with the manufacturer’s recommendations and requirements. Surface to be in contact with firestopping shall be cleaned of dirt, grease, oil, loose materials, rust, or other substance that may affect proper fitting or the required fire resistance.

D. Firestopping materials shall provide an effective barrier regardless of the geometric configurations of the void spaces. Firestopping materials for filling voids in floors having openings of four (4) inches or more shall be installed to support the same load as the floor is designed to support, unless the area is protected by a permanent barrier preventing loading or traffic on the fire-stopped area.

E. At a minimum fire stop systems shall be designed to achieve a 2-hour F rating with an emphasis on also achieving a 2-hour T rating. In addition to fire and thermal protection, fire stop systems shall be designed to provide a barrier to the transmission of smoke and toxic fumes.

F. A firestop system as defined by these specifications shall consist of fire barrier products, in certain configuration and quantity, to meet the intent of the specifications above. Fire protection products include:

1. 3M fire barrier CS-195 composite sheet
2. 3M fire barrier moldable putty
3. 3M fire barrier CP 25WB caulk
4. 3M fire barrier FS-195 wrap/strip

G. Firestop systems for floor and chase penetrations shall be installed on both sides of the penetration (top and bottom) (in and out). Firestop systems shall be symmetrically installed on both sides and shall meet or exceed all requirements for AT&T standard practices.

2.3 ELECTRICAL EQUIPMENT

A. General: Unless specifically specified or shown otherwise, the Contractor shall furnish required motors, variable speed drives with controls, and disconnect switches for equipment furnished under this Division. Motors, drives, and associated controls, and disconnecting equipment shall be provided where indicated and as required for operation of the equipment being furnished. Motors shall be designed for full voltage starting unless otherwise specified or noted on drawings and shall be suitable for continuous duty at 40 C. ambient. All motors shall be selected, designed and fabricated in conformance with the requirements of NEMA-MG-1 standard.

B. All motors shall be NEMA Design B induction motors with voltage and phase scheduled on drawings. Motors shall be equipped with Class F insulation, rated with a service factor of 1.15 and nominal full-load efficiency within 1.5% of the maximum values provided by the National Electrical Manufacturers Association Standard 12.6C in publication MG 1. The motor efficiency testing standards for all motors is IEEE Standard 112-1984, “Standard Test Procedure for Polyphase Induction Motors and Generators”. All motors shall have a 2% - 5% power factor improvement over typical standard efficient motors. Motors shall comply with the frame size assignments of NEMA MG 13-1984. Motor nameplate horsepower ratings shall not be exceeded when the equipment is operating within the limits of the design conditions specified. The motor loading shall not exceed the motor service factor rating on start-up conditions or at the equipment maximum load point.

C. Rating: Motor rating, service factor and nameplate data shall conform to the requirements of NEMA-MG-1 standards. Motor nameplate horsepower ratings shall not be exceeded when the equipment is operating within the limits of the design conditions specified. The motor loading shall not exceed the motor service factor rating on start-up conditions or at the equipment maximum load point.

D. Nameplate data shall conform to NEMA MG 1 requirements. For motors of one horsepower and greater, the following additional nameplate data shall be included:

1. Manufacturer’s identification number
2. Frame size number
3. Insulated system class designation
4. Service factor
5. Locked-rotor KVA code letter
6. Starting limitations (if any)
7. Hazard classification (if approved)
   a. Design and construction of each motor shall be coordinated with the driven equipment requirements.

E. Service factor - All motors of one horsepower and greater shall be furnished with a service factor of 1.15 in accordance with NEMA-MG-1.

F. Enclosures - All motors shall be self-cooled. Motors for indoor service shall have drip-proof enclosures. Motors for outdoor service shall be totally enclosed and shall have all exposed metal
surfaces protected, where practical, with a corrosion resistant polyester paint or coating. Exposed unpainted and uncoated metal surfaces shall be of a corrosion resistant material. All self-ventilated open type motors and the fan hoods of totally enclosed fan cooled motors shall meet NEMA MG 1 requirements for a fully guarded machine. Totally enclosed motors shall be furnished with cast iron frames, bearing brackets and terminal housings. Fan cooled motors shall have fans fabricated of corrosion resistant metal and cast iron fan covers.

G. Bearings for fractional horsepower motors shall be designed to operate in any position or angle. One-piece sleeve bearings with wick lubrication shall be furnished where available. Ball bearings shall be furnished where sleeve bearings are not available and where axial thrust loads exceed 20 pounds.

H. Bearings for motors of one horsepower and greater shall be oil lubricated sleeve bearings. If motor frame size is such that sleeve bearings are not available, bearings shall be grease lubricated rolling element type, self-lubricated and re-greaseable.

2.4 DISCONNECT SWITCHES

A. Material - Disconnect switches shall be NEMA type HD (Heavy Duty) quick-make, quick-break disconnect switches not furnished by others with equipment and where indicated on drawings or where required by Code. Switches shall be fusible or non-fusible as called for or as required. Switches shall have NEMA I enclosure unless otherwise specified or called for otherwise on drawings. Switches shall have door interlock and shall be padlockable in "open" and "closed" position. Where indicated for use in motor circuits utilizing VSDs switch shall be furnished with interlock contacts for interface with VSD, preventing operation of VSD when load is disconnected.

B. Reference E-series drawings and Division 26 for disconnect switches provided by electrical contractor. If not shown and required it is assumed the equipment manufacturer is providing it. If not, the contractor shall be responsible for all providing including all labor for installation.

2.5 MOTOR STARTERS

A. Starters shall be in accordance with NEMA ICS, UL 508 and the following paragraphs:

B. All starters installed indoors shall be in a NEMA 1 enclosure and all starters installed outdoors shall be in a NEMA 4 enclosure. Enclosures shall be designed for surface mounting unless otherwise indicated.

C. Each starter shall have a nameplate on the cover. Nameplates shall be made of laminated black and white plastic with the white on the outside. Lettering shall be bold, not less than 1/4 inch square, engraved through the white outside layer so that the letters appear black. Nameplate wording will be furnished as called for on drawings or as approved by the Owners Representative.

D. Magnetic starters shall include 480 volt, 3-phase, 60 hertz contractors with three manual reset thermal overload relays, 120 volt operating coils, and 480 to 120 volt dry type control transformers complete with one secondary lead fused and the other secondary lead grounded. Large size starters which require line voltage to energize the operating coils shall be equipped with auxiliary contractors for use in the operating coil circuit. These contractors shall be operated from the 120 volt circuit of the control transformers. Reduced voltage starters shall be closed transition auto transformer type equipped with taps for 50, 65 and 80 percent of full voltage. Two speed starters and reversing starters, shall be mechanically and electrically
interlocked so that only one set of contacts can be closed at any one time. Contractors shall have a current rating in accordance with NEMA standard ICS.

E. Two each normally open and normally closed interlock contacts shall be furnished with each starter as indicated. Additional interlocks shall be as called for on drawings.

F. Three thermal overload relays of the bimetallic strip or euthenic alloy type shall be furnished with each motor starter. Thermal overload relay heaters shall be sized to protect their associated motors of the circuits from damage due to overload. Provisions shall be made for manually resetting the thermal relay without opening the starter cover.

G. Control Transformers shall have 60 hertz ratings permitting operation at a primary voltage ranging from 208 to 240 volts. Assuming 208 volts on the primary terminals, each control transformer shall maintain a minimum potential of 105 volts at its secondary terminals during starter coil inrush, while simultaneously serving an additional load of 100 volt amperes at 50 percent power factor. Control transformers shall be mounted in the enclosure with the magnetic starter.

H. Each magnetic starter shall be equipped for control from local remote push-button or control switch, or other pilot devices as called for on drawings. All necessary internal wiring for this feature shall be supplied and connected to terminal blocks located to provide easy connection to the external control wiring.

I. A push to test running pilot light shall be provided and mounted in the cover of each magnetic starter to indicate when the motor is in operation. The light shall be of the transformer type with a 6 volt bulb and a red color cap.

J. Hand-Off-Auto" Selector Switch Units shall be provided and mounted in the cover of the starter as indicated in these specifications and as indicated on drawings. Units shall be heavy-duty, oil-tight and shall be complete with contact blocks and legend plates. Momentary contact "start-stop" push-buttons shall be provided with an auxiliary contact for use in the holding circuit.

K. Schematic Diagrams shall be as indicated on drawings or as approved by the Contracting Officer.

L. Each combination starter where indicated on drawings shall include a magnetic starter, as specified hereinbefore, and a disconnect switch or a fusible disconnect switch complete with fuses.

1. Each fusible disconnect switch unit shall include one 3 pole, 600 volt, quick-make, quick-break, manually operated switch connected in series with one replaceable dual element fuse per switch pole. The switch and fuse elements shall be sized according to the following:

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<tr>
<th>Starter Size</th>
<th>Fuse Clip Size</th>
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M. Fuses shall be UL 198D Class K5, 600 volt, and dual element type. Fuses shall have a thermal element that restricts the temperature rise to 280°F and an element of low peak type that limits the let through fault current. Fuses shall be rated at 200,000 amperes RMS symmetrical interrupting capacity and shall have a minimum time delay of 10 seconds at 500% of rating as specified hereinbefore.

N. A manual operating handle shall be mounted in the cover of each starter to operate the disconnect switch. The handle shall have provisions to lock in the open position with one or more padlocks. The cover and switch shall be interlocked so that the cover cannot be opened normally when the switch is in the closed position. Provisions shall be made for overriding this interlock.

O. Motor starters shall be wall or column mounted not more than six feet above the floor or mounted on the equipment if readily accessible from the floor or roof. Each starter shall be labeled on the cover as specified hereinbefore. The labeling shall be done with black letters on a white background. Letters are to be 1/4 inch high.

P. Nameplates - All major equipment items shall have a permanent stainless steel nameplate. Nameplates shall include the applicable items in the following list:

1. Manufacturer's size and type
2. Serial number
3. Design capacity
4. Design pressure
5. Design speed
6. Design temperature
7. Design static pressure "w.c."
8. Motor horsepower and RPM

Q. A permanently attached rotation arrow shall be provided on all items of rotating equipment.

PART 3 - EXECUTION

3.1 CUTTING AND PATCHING

A. The responsibility for any cutting of construction, which is required for the installation work, shall be by the Contractor. The Contractor shall coordinate with the Owner before any cutting and obtain approval from the Engineer and the Owner prior to any cutting.

B. Where openings for work within this Division are provided under other sections of the specifications, this Contractor shall be responsible for locating and providing the proper dimensions for all such openings.

C. Cutting shall be done with extreme care and in such a manner that the strength of the structure will not be endangered. Wherever possible, openings in concrete or masonry construction shall be by concrete saw or rotary core drill. Openings in any construction shall be cut the minimum size required for the installation of the work.

1. Adequate protection shall be provided to prevent damage to adjacent areas and to prevent dust from spreading to adjacent areas.
2. The use of jackhammers will not be permitted.
D. Where openings or holes are cut in existing construction and the cutting breaks existing electrical circuitry or control circuitry, or communications, conduit and wiring, then it shall be the responsibility of the Contractor to have the circuitry, conduit and rewiring re-routed and to complete the circuitry as required and as approved by the Owner. Temporary completion shall be provided where necessary before the permanent re-routing and completion work is finished. All costs for this work shall be the responsibility of the Contractor and no additions will be allowed to the Contract price.

E. Before any cutting, patching, or finishing work is started, dust and moisture protection shall first be installed as required to protect adjacent construction and equipment and to prevent dust spreading from the immediate area where work is being performed.

F. After any work is installed through any opening in walls, partitions, ceilings, or floors, the opening around the work shall be patched to match the existing construction, and the openings around pipe sleeves, between pipes and sleeves, and around ductwork shall be sealed watertight through floors and shall be sealed fireproof and smoke tight through floors, walls, partitions and ceilings.

G. Where existing work is removed from openings in existing construction and the opening is not to be reused for new work, the opening shall be filled and patched to match existing adjacent construction and to be watertight for floors and to be fireproof and smoke tight for floors and all other construction.

H. No structural member shall be cut without the approval of the Consultant, and all such cutting shall be done in a manner directed by him.

3.2 ELECTRICAL COORDINATION

A. All electrical products and installation used on this project shall conform unless otherwise specifically noted, to applicable standards of the National Electrical Manufacturers Association, NFPA 70, Division 26 of these specifications, and shall also be listed by Underwriter’s Laboratories, Inc. and/or other agencies, as required.

B. Electrical power sources and motor connections for all equipment shall be provided as specified within Division 26 of these specifications. All control wiring, safety interlock wiring, and temperature control system wiring required shall be furnished and installed as specified within these specifications. The control wiring shall include the furnishing and installation of all conduit, boxes, fittings, devices, accessories, wire, and connections required for complete and properly functioning systems. All wiring shall be installed in conduit, and all splices and connections shall be made in approved type enclosures or boxes.

1. If motors or controls are not shown on the Electrical Drawings, it has been assumed that these motors and controls have been wired as part of a piece of package equipment, or that control wiring will be run by the Contractor.

C. Reports: The Contractor shall submit to the Engineer, after mechanical systems are completely installed and operating under normal load conditions and prior to final acceptance of the project, four (4) copies of tabulated report on each piece of mechanical equipment motor and motor starter. The tabulated reports shall show the following information:

1. Mechanical equipment identification on which motor and starter is used
2. Motor nameplate horsepower, full load amperes, and voltage
3. Motor nameplate service factor and temperature rise
4. Actual (metered) motor running amperes and voltage
5. Motor starter nameplate: HP rating and voltage
6. Motor starter thermal overload protection unit current rating, manufacturer’s name and manufacturer’s catalog number marked on thermal units.

3.3 NOISE AND VIBRATION

A. Contractor shall be responsible for the installation of all equipment in such a manner as to control the transmission of noise and vibration from any installed equipment or system, so the sound level shall not exceed NC35, in any occupied space. Contractor shall be responsible for the correction of any objectionable noise in any occupied area due to improperly installed equipment.

3.4 TEMPORARY UTILITIES, SERVICES AND CONNECTIONS

A. The Contractor shall provide temporary electric power for construction purposes in accordance with all Codes and Ordinances and as required by projects. All temporary equipment, materials and connections required for the temporary services shall be furnished and installed by the Contractor. At the completion of the project or at such time as the temporary services are no longer needed, the Contractor shall remove all temporary equipment, materials, and connections and shall restore facilities to permanent finished conditions. Contractor may obtain temporary service from the existing building.

B. Temporary wiring connections and facilities shall be installed as required, so that all spaces, fixtures, devices, equipment, and circuits that are required to stay in operation do so, and so that interruptions in the use of any space, device, fixtures or piece of equipment can be held to the absolute minimum time possible.

C. Interruptions in existing utilities, services, or in the electrical circuitry and facilities shall be scheduled and sequenced as hereinbefore specified in this section of the specifications, and sequencing shall also conform to specific requirements as specified in other sections of the specification or as indicated on the drawings. The scheduling and sequencing shall be coordinated in advance with the Owner and Architect and shall be as approved by these parties. Even though a schedule is approved, the Owner shall also be notified immediately prior to any interruption in any electric facilities and circuits so that alternative arrangements can be made.

3.5 INSPECTION

A. Each bidder shall inspect the site as required for knowledge of existing conditions and failure to obtain such knowledge shall not relieve the successful bidder of the responsibility to meet existing conditions in performing the work under the contract.

B. Where new work cannot be installed without changes in existing plant, facility or systems or where it is indicated on drawings to rework an existing installation, this contract shall include alterations to existing work as required to install new work. Additions to the contract cost will not be allowed because of this Contractor’s failure to inspect existing conditions.

C. Where existing power, lighting, or control circuitry is broken by removal of existing devices, equipment, or fixtures, or by demolition work, cutting or removal of existing building construction, and where the existing circuitry is required by remaining devices or equipment to stay in service, then the circuitry shall be completed as required by job conditions.

D. Existing conditions indicated on the drawings are taken from the best information available on previous contract drawings and from visual site inspection and are not to be construed as "As-
Built conditions, but are to indicate the intent of this work. It shall be the responsibility of the Contractor to verify all existing conditions at the project site and to perform the work as required to meet the existing conditions and the intent of this work indicated.

3.6 TESTING

A. All electrical equipment furnished under this Division shall be adjusted and tested by this Contractor. Motors and other equipment furnished by others, to which electrical connections are made under this Division, shall be checked for short circuit and open circuits before energizing. Motors shall be checked for proper phasing and rotation. The thermal overload protection devices shall be checked in all motor starters, and equipment and all protection device size, motor nameplate full load amperage, and voltage rating for protection of the motor shall be listed (include equipment designation, rating of heater, motor nameplate horsepower, full load amps and voltage) and 4 copies of list shall be submitted to the Architect.

B. Mechanism of all electrical equipment shall be checked, adjusted and tested for proper operation. Protective devices and parts shall be checked and tested for specified and required application and adjusted as required. Adjustable parts of all lighting fixtures and electrical equipment shall be checked, tested and adjusted as required to produce the intended performance.

C. Completed wiring systems shall be free from short circuits and after completion, perform tests for insulation resistance in accordance with the requirements of the National Electrical Code.

D. The Contractor shall be held responsible for the operation, service and maintenance of electrical equipment during construction and prior to acceptance by the Owner. All electrical equipment shall be maintained in the best operating condition. Operational failure caused by defective material and/or labor furnished under this Division shall be immediately corrected. Architect shall be immediately notified of any operational failures caused by defective material and/or labor covered under other Divisions or furnished by others.

3.7 START-UP

A. All labor for the installation of material and equipment furnished under this Division shall be done by experienced mechanics of the proper trade and all workmanship shall be first class and in compliance with the specific requirements of drawings and specifications.

B. All material and equipment provided under this Division shall be installed under competent supervisory service furnished by the Contractor. Where necessary, this shall include the services of special erection and operation personnel.

C. The Contractor shall furnish all hoists, scaffolds, staging, runways, tools, machinery and equipment required for the performance of work.

D. Dirt and refuse resulting from the performance of the work shall be removed from the premises daily as required (broom clean) to prevent accumulation and the Contractor shall cooperate in the maintaining of reasonably clean premises at all times.

E. Immediately prior to the final inspection, Contractor shall clean all material and equipment. Dirt, refuse and stains shall be removed from all surfaces and damaged finishes restored to original condition.
3.8 TRAINING

A. The Contractor shall furnish all services as required for adequate verbal and printed instructions to the Owner and the Owner's operating and maintenance personnel for operation and maintenance of all equipment and systems installed under this Division. Three complete copies of service manuals in hardback binder shall be furnished at the end of the project in accordance with the General Conditions of the specifications. The manuals shall include printed operating and maintenance instructions for systems and equipment specified under this Division, all approved shop drawings and all manufacturer printed data.

B. When the work is complete and at a time designated by the Owner's designated Representative, the Contractor shall furnish the services of a qualified instructor to instruct the Owner's personnel in the operation and maintenance of the systems and equipment.

C. The bound copies of the operating and maintenance manuals shall be used during the verbal instructions.

END OF SECTION - 230500
SECTION 230501 - MECHANICAL PROJECT COORDINATION AND INSTALLATION

PART 1 - GENERAL

1.1 CONTRACTOR’S USE OF PREMISES

A. Confine operations at site to areas and limits permitted by law, ordinances, permits; Contract Documents and GENERAL CONDITIONS.

B. Protection and safekeeping of products stored on premises is responsibility of contractor supplying product.

C. Deliveries and unloading shall be scheduled to prevent traffic congestion blocking of access or interference with Work. Arrange deliveries to avoid larger accumulations of materials than can be suitably stored at site.

D. Contractor shall pay for, or satisfactorily repair, all damages incident to their Work, to sidewalks, streets, other public or private property, or to any public utilities occurring during period of work under this Contract.

1.2 HAZARDOUS MATERIALS

A. Submit Material Safety Data Sheets for all materials furnished in this project defined as hazardous by NFPA. All requirements of the Material Safety Data Sheets shall be implemented and followed judiciously when hazardous materials are installed or otherwise used.

B. All hazardous materials shall be stored and used (mixed, applied, etc.) in strict accordance with the OSHA Standards, Safety Data Sheets and the Owner’s Safety standards.

C. Refrigerants, nitrogen, welding gas, paints, varnish, volatile oils, etc., shall be stored in a room having good ventilation and containing no other material, or in metal lockers or barrels well away from structures or other combustible materials.

1.3 WELDING AND CUTTING

A. Special precautions shall be taken to reduce fire hazards where electric or gas welding or cutting work or soldering is done and suitable fire extinguishing equipment shall be maintained near such operations. Before proceeding with any electric or gas welding or cutting or soldering work in or adjacent to the existing building the Contractor shall obtain a permit from either the Engineer or Owner. The permit shall be issued by its authorized supervisor or representative certifying compliance with conditions set out in the permit pertaining to welding and cutting operations.

END OF SECTION - 230501
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SECTION 230516 – EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Flexible pipe connectors.
B. Flexible ductwork connections.
C. Alignment Guides and Anchors.
D. Pipe Loops and Swing Connections.

1.2 SUBMITTALS

A. Submit shop drawings for all flexible connectors in accordance with Division 1.

PART 2 - EQUIPMENT

2.1 PIPING FLEXIBLE CONNECTIONS

A. Material - Flexible pipe connectors for installation in supply and return water connections to water coils in air handling units shall be multiple arch TFE T62 Teflon with Monel reinforcing rings, control units and 150# ANSI flanged ends. Connectors shall have minimum live length of not less than recommended by the connector manufacturer for vibration isolation.

B. Manufacturer:
   1. Resistoflex
   2. Mason Industries.

2.2 FLEXIBLE DUCT CONNECTIONS

A. Material - Flexible duct connections shall be made with 30 oz. non-combustible, waterproof and mildew-resistant double polychloroprene coated glass fabric. Connections shall be not less than 4" long, shall have suitable metal collar frame at each end and shall be made with not less than 1" slack in material to prevent transmission of vibration.

   1. At flanged equipment connections, bolt companion flange, continuously brazed to minimum 3-inch extension collar and minimum same gage as connecting duct.

B. Manufacturer:
   1. Duro Dyne Corp.: Metalfab Canvas
   2. Flow-Flex Eng. Co.: Fabric Connectors
   3. Ventfabrics, Inc.: Ventfab Metaledge

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

1. **Description:** Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. **Anchor Materials:**

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

5. **Chemical Fasteners:** Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. **Bonding Material:** ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   b. **Stud:** ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
   c. **Washer and Nut:** Zinc-coated steel.

PART 3 - EXECUTION

3.1 **METHOD OF INSTALLATION**

A. Provide flexible pipe connectors in the suction and discharge connections, the supply and return water connections of coils in all air handling units; and elsewhere where shown on drawings.

B. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Install flexible pipe connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Rigidly anchor pipe to building structure; provide pipe guides so that movement takes place along axis of pipe only. Install expansion joints along axis of pipe.

C. Furnish and install flexible duct connections for equipment supported on vibration isolation.

3.2 **PIPE LOOP AND SWING CONNECTION INSTALLATION**

A. Chapter 46, "Pipes, Tubes, and Fittings," in the 2012 ASHRAE HANDBOOK - "HVAC Systems and Equipment," states that cold springing is not recommended for most HVAC piping. If retaining first paragraph below, indicate dimensions of loops and swing connections and locations of guides and anchors on Drawings.

B. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

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

E. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT- GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

1. Anchor Attachments:
   b. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

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

1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer’s written instructions.

F. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION - 230516
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SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Liquid-in-glass thermometers.
2. Duct-thermometer mounting brackets.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Flowmeters.
7. Thermal-energy meters.

1.2 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1, Section 013300.

B. Submit the following:

1. Product Data: For each type of product.
2. Diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 LIQUID-IN-Glass THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

2. Case: Cast aluminum, 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle (when installed over 6'-0" from floor), Straight (when installed lower than 6'-0" above floor) unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue (for cold water systems) or red (for hot water systems) organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Stem: Stainless Steel and of length to suit installation, with extension as required for insulated piping or ductwork.
   b. Design for Thermowell Installation: Bare stem.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.
2.3 THERMOWELLS

A. Thermowells:

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

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

2.4 DIAL-TYPE PRESSURE GAGES

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

2. Case: Field Liquid Filled type(s); 304 stainless steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
9. Ring: Bayonet Type, 304 Stainless steel.
10. Accuracy: ASME B40.100 Grade 1A, ±1.0% Full Scale.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.
D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install valve and snubber in piping for each pressure gage for fluids (except steam).

I. Install test plugs in piping tees.

J. Install thermometers in the following locations:
   1. Inlet and outlet of each hydronic zone.
   2. Inlet and outlet of each hydronic boiler.
   3. Inlet and outlet of each chiller.
   4. Inlet and outlet of each hydronic coil in air-handling units.
   5. Two inlets and two outlets of each hydronic heat exchanger.
   6. Inlet and outlet of each thermal-storage tank.
   7. Outside-, return-, supply-, and mixed-air ducts.

K. Install pressure gages in the following locations:
   1. Discharge of each pressure-reducing valve.
   2. Inlet and outlet of each chiller chilled-water connection.
   3. Suction and discharge of each pump.

3.2 CONNECTIONS

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

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.

C. Scale Range for Air Ducts: 0 to 100 deg F.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 psi.

B. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.
END OF SECTION - 230519
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SECTION 230523 – HVAC VALVES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. HVAC Valves:

1. Ball Valves
2. Butterfly Valves
3. Globe Valves
4. Check Valves
5. Pressure and Temperature Relief Valves

1.2 QUALITY ASSURANCE

A. Valves shall be of the same manufacture throughout, where possible. Manufacturer’s name and pressure rating shall be located on outside of valve.

B. Unless noted otherwise, cut-off valves shall be ball valves or butterfly valves. Flow control (balancing) valves shall be per specification section 232116 “Hydronic Specialties.”

C. Cut-off valves used in water and water/glycol systems including chilled, process chilled, condenser, heating and process heating shall be ball valves for 2” size and smaller, and shall be butterfly valves 2½” size and larger.

1.3 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1 and as follows:

1. Submit copies of valve ordering schedule for approval before ordering valves.
2. Submit detailed shop drawings indicating make, model, location, type, size, and pressure rating.

PART 2 - EQUIPMENT

2.1 BALL VALVES

A. Ball valves shall be manufactured to comply with MSS SP 110 and shall be 3-piece type. Valves shall be all bronze (B-584 or B-62) with stainless steel ball, full port and shall be designed for 150 PSI, 600 WOG; working temperature range of at least 0°F. to 300°F. Ball valves shall be three-section assembly with Double-O ring seal and removable center section with replaceable Teflon, TFE seats. Ball valves shall have blow-out proof stem with high extended stem to provide for insulating, lever type handle with vinyl grip and 90° stop on the extended stem. All valve stem housings shall be of length to receive up to 1½" thick insulation and shall have NiB seal valve extension.

B. Manufacturer

1. Ball valve manufacturers for HVAC applications
   a. Nibco
   b. Stockham
   c. Jamesbury
2.2 BUTTERFLY VALVES:

A. Butterfly valves shall be manufactured to comply with MSS SP68.

B. The valve body shall be carbon steel construction, lug style design, suitable for bidirectional dead-end service at rated pressure without use of downstream flange. The valve shall have a CWP rating of 285 psig at 100°F. The lug style body shall be drilled and tapped for isolation and removal of downstream piping. The valve body shall have an extended neck of sufficient length such that 2 inch, pre-molded fiberglass insulation and jacketing can be installed up to and around the valve neck. The neck extension shall allow sufficient clearance for valve operator without damage to the insulation.

C. The valve disk and stem shall be of stainless steel construction, with reinforced PTFE seats.

D. Manufacturer

1. Keystone HS2
2. Bray
3. DeZurik
4. NIBCO

2.3 GLOBE VALVES:

A. Globe valves in piping 2" and smaller shall be bronze, rated at 150 psig-swp and provided with a union bonnet, composition disc and screwed ends.

B. Globe valves in copper tubing shall be bronze, rated at 300 psig-wog and provided with a screwed bonnet, composition disc, solder ends.

C. Globe valves in piping 2½" and larger shall be iron body, bronze mounted, rated at 125 psig-swp and provided with a composition disc, outside screw and yoke and flanged ends.

D. Manufacturer(s): Basis of Design.

1. Globe valves in piping 2" and smaller shall be Stockham B-22.
2. Globe valves in copper tubing may be Stockham B-14T.
3. Globe valves in piping 2½" and larger shall be Stockham G-514T.
4. Equals include NIBCO and McDonnell

2.4 CHECK VALVES

A. Check valves in HVAC applications shall be spring-loaded, non-slamming, silent closing, with renewable seat and disc guided at both ends, stainless steel or bronze trim, and rated for not less than 250 psi cold water working pressure at temperature up to not less than 100°F. Valves shall close off bubble-tight. Valves 1½" and smaller shall have bronze body and screw ends, and valves 2" and larger shall have globe style body of carbon steel, ductile iron, or semi-steel, and with ANSI Class 150 pound flanged ends.

1. Manufacturer
   a. Mueller Steam Specialty Co
   b. Keystone
   c. Metraflex
2.5 PRESSURE & TEMPERATURE RELIEF VALVES

A. Material - Pressure and temperature relief valves shall be designed, constructed and rated to ASME Code. Valves shall have a capacity at pressure indicated on drawings, in Btu's/Hr. of not less than capacity of units which they protect, and they shall have test levers. Extend relief line full size and end over drain.

B. Manufacturer

1. Watts
2. McDonnell
3. NIBCO

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Valves shall be installed within each system to provide the required flow control and to provide isolation for inspection, maintenance and repair of each piece of equipment and each main and branch service loop. The foregoing shall apply whether or not valves are shown on drawings. Valves shall also be installed in other locations shown on drawings. Each valve shall be installed so as to be easily accessible for operation and visual inspection after construction is complete.

1. A union connection shall be installed within two feet and on each end of a screw end valve (Reference Section 232113 for piping unions). Valves and specialty items shall be rated for not less than the cold water working pressure and the test pressure specified for each piping system.

END OF SECTION - 230523
SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Piping Hangers and Supports
B. Duct Hangers and Supports
C. Roof Mounted Curbs and Equipment Supports

PART 2 - EQUIPMENT

2.1 PIPING HANGERS AND SUPPORTS

A. Provide factory-fabricated horizontal piping hangers, clamps, attachments and supports in compliance with ANSI SP-69 and ANSI SP-89. Select hangers and supports sized to exactly fit pipe size for bare piping, and to exactly fit around pipe insulation with saddle and shield for insulated piping. Hangers in contact with copper pipe shall be copper plated.

B. Unless specified otherwise, pipes shall be hung with malleable iron, split ring hangers or clevis hangers not less than 1/8" thick. Strap type hangers shall not be acceptable. Roller type hangers shall be used where required or shown to allow for movement of pipes by expansion. Hangers shall have rods and turnbuckles of required length. Suspension shall be from suitable steel supports fastened to overhead construction or steel wall brackets. Hangers and supports shall be installed so that pipes are run parallel and evenly spaced.

C. Anchors in concrete construction shall be threaded compound type or Phillips self-drilling type of sufficient size to adequately support the load.

D. Manufacturer:

1. Hangers and supports:
   b. Kindorf Mfg.
   c. Unistrut Mfg., Inc.
   d. Fee Mfg.

2.2 DUCT HANGERS AND SUPPORTS

A. Material - Duct hangers shall be galvanized steel band iron or 1¼" x 3/16" angle and 3/8" rods. Wall supports for ductwork shall be galvanized steel band iron or fabricated angle bracket. Support vertical ductwork at floor with rolled 1¼" x 3/16" structural steel angle.

B. Duct Supports: Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts straight, plumb, free of sags and vibration, and to prevent buckling. Support ductwork from building structure where not otherwise indicated, anchor with bolts, concrete inserts, welded studs, C-clamps, or special beam clamps with support as indicated in the SMACNA Standards. Anchor methods other than listed shall receive prior approval from Owner before using. Support vertical ducts, at every floor, 12-foot maximum spacing, by attachment to adjacent vertical structural surfaces or by direct bearing at floor penetrations and similar locations.
2.3 ROOF MOUNTED CURBS AND EQUIPMENT SUPPORTS

A. Unless noted otherwise, contractor shall be responsible for providing curbs and supports for all equipment to be installed on roof. Contractor shall coordinate equipment specifications and locations with each piece of equipment to ensure equipment is properly supported.

B. Curbs and equipment supports for roof mounted equipment shall be of monolithic construction, not less than 18 ga. galvanized steel, with continuous welded corner seams, factory installed wood nailer, built-in raised cant of height as required for thickness of roof insulation, and base as required for attaching to the roof structure.

C. Curbs shall be internally insulated with 1½" thick, 3 lb. density rigid glass fiber board and shall have galvanized sheet metal liner. Equipment supports shall have integral base plate, wood nailer, and 18-gauge galvanized steel flashing cap.

D. Curbs and equipment supports shall be of size as required to properly mate with equipment to be mounted on the curbs or supports and shall be designed and constructed to safely support the weight of the equipment. The height of curbs shall be as indicated on drawings, but not less than 13½" high above the roof deck, unless called for or specified otherwise.

E. The curbs and supports shall be securely attached to the roof structure to withstand wind pressures on the vertical surface of the curb or supports and the mounted equipment by wind velocities up to 100 MPH. The complete installation shall be made watertight and shall be coordinated with the roofing installer.

F. Curbs which serve grease laden applications shall be ventilated and uninsulated. Coordinate with tenant infill plans for quantity and location of applicable equipment.

G. Manufacturers:

1. Roof Curbs
   a. Pate Manufacturing Company: PC-2
   b. Thycurb
   c. Custom Curb

2. Equipment Supports
   a. Pate Manufacturing Company: ES-5A
   b. Thycurb
   c. Custom Curb

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Comply with MSS SP-69 and SP-89 for installation of hangers, supports and anchors. Install hangers, supports, clamps, and attachments directly from building structure complete with inserts, bolts, rods, nuts and washers, and washers, and accessories. Do not use wire or perforated metal to support piping; pipe support from other piping shall not be permitted. Install hangers with minimum ½" clear space between finished covering and adjacent work. Place hanger within 1 foot of each horizontal elbow. Use hangers vertically adjustable 1½" minimum after piping is erected.
B. Insulated pipe, hangers and supports shall be furnished with ribbed galvanized steel shields of not less than 18 gauge; two-piece pre-molded, high compressive strength, insulation inserts (360° around pipe); and vapor barrier jacket covering the insulation inserts. Inserts shall be constructed of high density, 100 psi, waterproofed calcium silicate, encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation.

C. Maximum spacing of hangers and supports shall be in accordance with the following schedule for size of pipe:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Rod Size</th>
<th>Ferrous Pipe</th>
<th>Copper Pipe</th>
<th>Plastic Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>¼&quot; &amp; ¾&quot;</td>
<td>¼&quot;</td>
<td>8'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4'-0&quot;</td>
</tr>
<tr>
<td>1&quot; &amp; 1¼&quot;</td>
<td>3/8&quot;</td>
<td>9'-0&quot;</td>
<td>7'-0&quot;</td>
<td>4'-6&quot;</td>
</tr>
<tr>
<td>1½&quot;</td>
<td>3/8&quot;</td>
<td>9'-0&quot;</td>
<td>8'-0&quot;</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>2&quot; &amp; 2½&quot;</td>
<td>3/8&quot;</td>
<td>10'-0&quot;</td>
<td>9'-0&quot;</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>3&quot; &amp; 4&quot;</td>
<td>5/8&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
<td>6'-0&quot;</td>
</tr>
<tr>
<td>6&quot; to 12&quot;</td>
<td>7/8&quot;</td>
<td>14'-0&quot;</td>
<td>7'-0&quot;</td>
<td></td>
</tr>
<tr>
<td>14&quot; to 18&quot;</td>
<td>1&quot;</td>
<td>20'-0&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D. Hangers for cast iron pipe shall be installed on maximum 5'-0" centers.

E. Supports on masonry walls shall have bolts through wall fastened to suitable steel plate on back of wall. Where required to allow for movement of pipe by expansion due to short hanger rods, pipes shall rest on rollers and covering protection saddles. All piping shall be supported and secured as required to prevent vibration and the transmission of noise and lateral movement.

F. The Contractor shall furnish and install all necessary material, hangers and support including all structural steel members and shapes to substantially support and/or suspend all piping and equipment, in an approved manner. Perforated strap hangers will not be acceptable.

1. Drive screws, pins, studs, etc., which are secured in place by means of explosive force will not be permitted.
2. Except as specifically otherwise approved, no item of equipment shall support any pipe or duct nor shall any item of equipment be supported on any pipe or duct.

G. Hangers shall be provided at every item of equipment and at every change in direction or branch connection to every pipe.

H. All pipes through roof shall be installed with sleeves and openings, and with roof flashing/counterflash assembly or pipe curb assembly as herein specified. The complete installation shall be coordinated with the roofing installer and shall be watertight and weather tight.

I. Sleeves shall be steel pipe and shall be installed for single pipe installation. Openings shall be boxed out for multiple installations. Sleeves for acid waste vent stacks shall be installed as specified under the heading: Sleeves and Openings.

J. Single, un-insulated pipes through roof shall be installed with flashing/counterflushing assembly with four pound seamless lead flashing assembly with 8" high boot and not less than 8" skirt. A conical shaped steel reinforcing boot underneath lead flashing assembly shall also be installed. Cast iron counterflushing fitting with rust-resistant prime coat, of the caulking type to fit over all types of piping, vandal-proof set-screws for anchoring in place, and top annular space for sealant
HANGERS AND SUPPORTS FOR HVAC EQUIPMENT

fill shall also be installed for single, un-insulated pipes. Assemblies shall be furnished in sizes to properly fit size of pipe with which they are installed. Flashing assembly shall be designed to fit properly on roofs from level up to 20° pitch. Top of flashing cone shall be sealed before installing counterflash fitting. Annular space in top of counterflash fitting shall be completely filled with epoxy sealing compound.

K. Grouped multiple pipes through roof and insulated pipes through roof shall be installed with factory prefabricated metal curb assembly of unitized construction of not less than 18 ga. galvanized steel with base plate for anchoring to roof deck or roof slab. The cant base for roof insulation thickness shall match the thickness of insulation where it is to be installed. A wood nailing strip shall be installed on top of the curb, and shall have 1¾" thickness of 3 lb. density fiberglass insulation on inside, and not less than 11" high from base to top of wood nailer. The curb assembly shall also have an acrylic clad ABS plastic flashing cover with number and size of formed openings as required for the number and size pipes through roof, along with a graduated step neoprene boot for each pipe. A neoprene boot shall be secured around pipe and around formed opening in flashing cover with stainless steel clamps for waterproof connections. Insulation on insulated pipes shall be continuous through the curb, flashing cover, and the neoprene boot. After roofing is flashed up over the curb and secured in place, the ABS plastic flashing cover shall be installed over curb and flash roofing and anchored in place for a watertight and weather tight installation.

L. Furnish and set all boxouts for openings and all sleeves for work to be installed under this division. Sleeves shall be installed for all pipes passing through floors, walls, and partitions. All sleeves shall be set tight in construction, without space between the sleeve and construction. Sleeves through walls and partitions shall be flush at each end and sleeves through floor shall extend 2" above finished floor unless indicated otherwise.

M. Sleeves through concrete slabs, concrete walls, and bearing masonry walls shall be steel pipe of not less than Schedule 30. Sleeves through non-bearing wall and partitions may be Schedule 10 pipe or 22 ga. sheet steel with formed bead on each end.

N. The annular space around bare pipes and pipe insulation on insulated pipes through sleeves shall be packed tightly with mineral wool to prevent transmission of air and sound. Each end of sleeve at floors and through fire-rated walls shall also be sealed with 1" thickness of waterproof and fireproof caulk equivalent to 3M #CP25 fireproofing caulk.

O. Sleeves for round and rectangular ducts shall be galvanized steel. Sleeves through fire and smoke walls shall comply with NFPA 90A. Size sleeves to allow for expansion movement and to provide for continuous insulation.

P. Duct Hangers and Supports Installation

1. Provide and install duct hangers and supports as indicated on the following schedule:
2. Low velocity ducts hanger minimum sizes:
   a. Up to 30" wide: 1¼" x 3/16" angle at 10 feet spacing
   b. 31" to 48" wide: 1½" x 3/16" angle at 10 feet spacing
   c. Over 48" wide: 1½" x 3/16" angle at 8 feet spacing
3. Horizontal duct on wall supports minimum sizes:
   a. Up to 18" wide: 1½" x 16 gauge or 1" x 1/8" at 8 feet spacing
   b. 19" to 40" wide: 1½" x 1½" x 1/8" at 4 feet spacing

Q. Assemble and install ductwork in accordance with SMACNA standards, in a manner which will achieve air-tight and noiseless systems, capable of performing each indicated service. Align
ductwork accurately at connections. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts straight, plumb and free of sags and vibration. Ducts shall be supported with steel rods of not less than 3/8" diameter or not less than 1" wide, 16 gauge galvanized steel straps.

R. Support ductwork from building structure where not otherwise indicated, anchor with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or special beam clamps. Supporting ductwork from piping, electrical equipment or cable trays will not be permitted.

S. Arrange hangers, supports and duct resets to permit free, unrestrained and noiseless expansion and contraction of duct. Vertical members may be fastened to duct sides with sheet metal screws. Seals all screw attachments to ductwork with mastic and seal gas tight.

T. Each Contractor shall provide all structural steel and materials necessary to properly support and anchor equipment and lines provided under this contract.

U. All equipment and materials shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and suitable for the service required.

V. Concrete bases shall be provided where shown on the drawings. Equipment which is to be grouted in place shall be grouted with Embeco or approved non-shrink grout.

END OF SECTION
SECTION 230548 – HVAC VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Open-spring isolators.
   3. Housed-spring isolators.
   4. Spring hangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
   1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Welding Certificates

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
   2. Size: Factory or field cut to match requirements of supported equipment.
   3. Pad Material: Oil and water resistant with elastomeric properties.
   4. Surface Pattern: Ribbed or Waffle pattern.
   5. Infused nonwoven cotton or synthetic fibers.
2.2 OPEN-SPRING ISOLATORS

A. 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 steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.3 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing.

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. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
   b. Top housing with threaded mounting holes and internal leveling device.

2.4 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.
PART 3 - EXECUTION

3.1 APPLICATIONS

A. General: Provide vibration isolators as indicated below:

1. Air Handling Units
   Elastomeric Pads
2. Vane Axial or In-line Exhaust Fans
   Spring Hanger Isolators
3. Centrifugal Exhaust Fans
   Free Standing Spring Isolators
4. Pumps
   Elastomeric Pads
5. Chillers
   Elastomeric Pads
6. Heating Hot Water Skids
   Elastomeric Pads
7. Pumping Skids
   Elastomeric Pads

3.2 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. 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.

F. 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.

G. 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. 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 post connection testing has been approved), and with at least seven days' advance notice.
   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.
   7. Measure isolator deflection.
   8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust isolators after piping system 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.

END OF SECTION
SECTION 230553 - HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Mechanical Identification for:

1. Ductwork systems
2. Piping system
3. Valves
4. Mechanical equipment
5. Warning signs
6. Control devices and wiring
7. Painting

1.2 SUBMITTALS

A. Submit shop drawings in accordance with General Requirements, Division 1.

B. Submit copies valve schedule for each piping system, typewritten and reproduced on bond paper. Tabulate valve number, piping system, system abbreviation, location of valve and variations for identification. Mark valves which are intended for emergency shut-off and similar special uses, by special "flag", in margin of schedule. Include valve schedules within Maintenance Manuals (Re: 230500) and Division 1.

PART 2 - EQUIPMENT

2.1 Mechanical Identification Materials


B. Valve tags: 19 gauge polished brass, 1-1/4" diameter, stamp engraved black enamel fitted. Valve tag fastener shall be solid brass chain.

1. At Contractors option, valve tags may be 3/32" thick engraved plastic laminated valve tags, within piping system abbreviation in ¼" high letters and sequenced valve numbers ½" high letters, and with 5/32" hole for fastener. Valve tag shall be white with black lettering.

C. Valve schedule frames: For each page of valve schedule, provide glazed display frame with screws for removable mounting on masonry walls. Frame shall be extruded aluminum with SSB-grade sheet glass.

D. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
Design and Construct TASMG Readiness Center – Army Aviation Site – Springfield, MO  
Project Number T1809-01

4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
E. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
F. Lettering Size: At least 3/4 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 DUCTWORK IDENTIFICATION

A. Identify air supply, return, exhaust, intake and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow. Locate identification in each space where ductwork is exposed, or concealed only by removable ceiling system and near points where ductwork originates or continues into concealed enclosures, (shaft, underground or similar concealment) and at 50 foot spacing along exposed runs.
B. Access doors shall have stenciled type signs on each access door in ductwork and housings. Indicate purpose of access (to what equipment); and other maintenance and operating instructions, and appropriate safety and procedural information.
3.3 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Pipe Label Color Schedule shall be per the following table:

<table>
<thead>
<tr>
<th>Pipe System</th>
<th>Legend</th>
<th>Letter Color</th>
<th>Background Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Pressure Steam (15psig)</td>
<td>LPS</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Heating Hot Water Supply</td>
<td>HHWS</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Heating Hot Water Return</td>
<td>HHWR</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td>Chilled Water Supply</td>
<td>CHWS</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Chilled Water Return</td>
<td>CHWR</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Low Pressure Condensate</td>
<td>COND</td>
<td>Black</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

3.4 VALVE IDENTIFICATION INSTALLATION

A. Valve tag location: Provide valve tag on all valves, cocks, and control devices in each piping system. List each tagged valve in valve schedule for each piping system. Mount valve schedule frames and schedules in machine room where directed by Owner’s Representative.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

A. Install engraved plastic laminate signs except where lettering larger than 1" is required for proper identification. Locate signs in or near each piece of mechanical equipment and each operation device.

1. Provide plastic laminated signs at main control and operating valves, fans, pumps, meters, gauges, thermometers, thermostats, VAV boxes, fan terminal units, duct mounted coils, control devices, sensors, fans and primary balancing dampers.
2. Laminated tags, at a minimum, shall be provided for each piece of equipment scheduled on drawings.

B. All temperature sensors, differential pressure switches, and control devices integrated with the building control systems shall be permanently marked to indicate normal operating points or range for both summer and winter operation. Coordinate with Engineer and Owner prior to marking. In addition, all room sensors shall have laminated tags mounted adjacent to the room sensor on wall or within the cover of the sensor itself. The laminated tag shall indicate the device which the sensor serves; (RC-1, VAV-1 etc.).
3.6 WARNING AND DANGER SIGNS

A. Where identifications signs are required to indicate a warning or danger, signs shall be plastic laminated with red background and white lettering. At a minimum warning signs shall be provided as follows:

1. All air handling unit access doors to fans and access doors downstream of fan discharge and elsewhere as required, to indicate an unsafe condition.
2. All motor driven equipment that automatically starts shall include a warning sign indicating such. Coordinate wording of danger sign with facility manager.

END OF SECTION

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SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Air and hydronic balancing of air handling systems including chilled water coils, heating hot water coils, variable air volume terminal units, exhaust fans, etc.

B. Air balancing of each diffuser, grille and register at air volume indicated on the drawings.

C. Start-up of services for air handling units, variable air volume terminal units, exhaust fans, chillers, boilers, pumps, electronic control systems, etc.

D. Validation assistance of control systems.

1.2 QUALITY ASSURANCE

A. Testing, balancing and start-up services shall be done by an Independent Contractor. The Independent Contractor shall have a proven record of doing TAB work for a period of at least 3 years. At the Owners request, references may be requested from the Contractor to verify past performance.

B. Submit evidence that personnel who perform testing and balancing of project systems are qualified personnel; for review and approval by Owner prior to performing work.

C. Submit list of completed projects successfully tested and balanced by submitted, qualified personnel for review and approval by Owner prior to performing work.

D. Perform all corrective measures caused by faulty installation; re-test, re-adjust and re-balance systems until satisfactory results are achieved.

E. Qualified personnel are:

1. Personnel certified by one of the following organizations:
   a. AABC - Associated Air Balance Council
   c. NEBB - National Environmental Balancing Bureau

2. Personnel Registered as a Professional Engineer.

1.3 SUBMITTALS

A. Preliminary:

1. Submit three copies of documentation to confirm compliance with Quality Assurance provisions:
   a. Organization supervisor and personnel training and qualifications
   b. Specimen copy of each of report forms proposed for use

B. Second: At least fifteen days prior to starting field work submit three copies of the following:
1. Set of report forms filled out indicating design flow values and required CFM for all diffusers.

Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each instrument. Furnish the following information:
   a. Manufacturer and model number
   b. Description and use when needed to further identify instrument
   c. Size or capacity range
   d. Latest calibration date

2. Engineer will review submittals for compliance with Contract Documents and return one set marked to indicate the following:
   a. Discrepancies noted between data shown and Contract Documents
   b. Additional or more accurate instruments required
   c. Requests for re-calibration of specific instruments

C. Third: At least fifteen days prior to Contractor’s request for final inspection, submit three copies of final reports on applicable reporting forms for review.

1. Schedule testing and balancing of parts of systems delayed due to seasonal, climatic, occupancy or other conditions beyond control of Contractor as early as proper conditions will allow, after consultation with Engineer.
2. Submit reports of delayed testing promptly after execution of those services.
3. Form of Final Reports:
   a. Each individual final reporting form must bear signature of person who recorded data and TAB supervisor of reporting organization.
   b. When more than one certified organization performs TAB services, the firm having managerial responsibility shall make the submittals.

PART 2 - EXECUTION

2.1 START-UP SERVICES

A. Prior to beginning Testing, Adjusting and Balancing (TAB) work the Independent TAB Contractor shall perform all start-up services as follows:

1. Inspect all bearings for cleanliness and alignment. Bearings which are found to be defective shall be noted as such to the Owner for replacement by the installing Contractor. Grease as necessary all bearings in accordance with the manufacturer’s instructions.
2. Adjust tension for all drives and adjust variable pitch drives to the RPM scheduled or noted on shop drawings.
3. Check each motor for amperage comparison to nameplate value. Motors which produce excessive current flow shall be noted as such to the Owner so corrections can be made by the installing Contractor.
4. Check electrical control circuits to insure that operation complies with the Specifications.
5. Inspect each pressure gage and thermometer for calibration.
2.2 HYDRONIC BALANCING

A. Make measurements in accordance with recognized procedures and practices of certifying association. Water flows shall be balanced to within ± 5 percent of design requirements.

B. Check conditions at cooling and heating coils for required performance at design conditions.

C. Mark all balancing devices as specified.

2.3 AIR BALANCING

A. Make measurements in accordance with recognized procedures and practices of certifying association. Measure air volume discharged at each outlet and adjust air outlet to design air volumes within ± 5 percent. Adjustments made for building envelope to maintain pressure relationship specified hereinbefore shall be coordinated with the Owner.

B. Adjust fan speeds and motor drives within drive limitations for required air volume. Set speed to provide air volume at farthest distance without excess static pressure.

C. Mark all balancing dampers and cocks.

D. Upon completion of addition, Test & Balance contractor shall be responsible for balancing new rooftop air handling and dedicated outside air energy recovery units.

2.4 COORDINATION

A. Coordinate services with work of various trades to insure rapid completion of services.

B. Promptly report to Engineer any deficiencies noted during performance of services to allow immediate corrective actions to be performed.

END OF SECTION 230593
SECTION 230713 – HVAC DUCT INSULATION

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK
A. Duct Insulation

1.2 RELATED DOCUMENTS
A. American Society for Testing and Materials
   1. Flame Spread: 25 or less; ASTM E84, NFPA 255
   2. Smoke Developed: 50 or less; ASTM E84, NFPA 255

B. National Fire Protection Association, NFPA:
   1. Composite ductwork lining installation including lining, sealers, mastics and adhesives, NFPA 255 method with Flame spread rating 25 or less and Smoke developed rating: 50 or less.
   2. NFPA No. 90A and 90B

1.3 QUALITY ASSURANCE
A. Insulation shall not be applied until all ductwork has been tested and approved and thoroughly cleaned. All insulation work shall present a neat appearance with smooth and uniform surfaces. Work done in a slovenly manner will not be acceptable. All insulation joints shall be carefully fitted and tightly butted. All jacket materials shall be neatly applied with smooth surfaces and shall be securely adhered or pasted in place. All seams and joints shall be located so that they are as inconspicuous as possible. Exposed edges and ends of all insulation shall be sealed and finished to provide a complete, unbroken vapor seal. The Contractor shall install insulation to be continuous through pipe sleeves.

B. Failure, due to faulty workmanship or material, of any portion of the installed insulation to perform the function as intended by these specifications, either stated or implied, for a period of one (1) year after acceptance of the project by the Owner, shall be the responsibility of the Contractor and shall be rectified at no additional cost to the Owner. This shall include the loosening of any jacket material, the appearance of condensation on the outside of the insulation, or any other mechanical or thermal failure which affects either appearance or efficiency of installation.

1.4 SUBMITTALS
A. Submit shop drawings for all insulating materials in accordance with Division 1.

B. Shop Drawings:
   1. Submit shop drawings which indicate complete material data, mastics, adhesives, list of materials proposed for this project and indicate thickness of material for individual services.

C. Product Data:
   1. Provide current manufacturer’s data to show compliance with these specifications and governing regulations; include proof of compliance for test products of products for fire and smoke rating, corrosiveness and compressive strength.
PART 2 – EQUIPMENT

2.1 DUCT INSULATION

A. Material - Insulate all new supply air and outdoor air intake ducts, exhaust air ducts, ductwork exposed to outdoor weather, ducts located where the ambient temperature is greater than the temperature of the air within the duct system and at all locations where condensing on ductwork is possible unless noted otherwise with 1½” thick flexible glass fiber blanket, approximately 1 lb/cu ft density, with a K value of 0.26 at 75° F. The insulation shall be suitable for temperatures up to 250° F. Furnish and install insulating jacket, Factory-applied foil-scrim-kraft vapor barrier.

B. Manufacturer:

1. Certain-Teed Corp: Standard Duct Wrap Type IV
2. Knauf: Duct Wrap-FSK
3. Manville Corp.: R Series Microlite-FSKL
4. Owens-Corning: Faced Duct Wrap-FRK 25-

PART 3 – EXECUTION

3.1 METHOD OF INSTALLATION

A. Duct Insulation:

1. Systems shall be completely covered throughout, including fittings and accessories. All fittings and accessories shall be accessible for maintenance. Unless specified otherwise, insulation shall extend continuous through sleeves.

2. All adhesives, tape and any other material used for sealing shall be applied in strict accordance with manufacturer’s instructions which includes covering rate of application, method of application, temperature limits for application of said materials, or any other condition affecting efficiency or permanence of the installation.

3. All external surface of ductwork shall be wiped clean before installation of insulation. Insulation shall be wrapped on exterior of ductwork with all joints butted and all longitudinal seams overlapped not less than 2”. Insulation shall be adhered to metal ductwork with not less than 4” strips of insulation adhesive, applied to ductwork at not greater than 8" O.C. On ducts wider than 18", the insulation on bottom of ductwork shall be additionally secured with welding pins secured to ductwork at not greater than 18" O.C. All joints, all longitudinal seams, all welding pins, and all penetrations shall be applied so that compressed thickness at corners of ductwork is not less than 1”. Seal joints and breaks (in ducts conveying air at less than room temperature) with 4” wide strips of open mesh glass cloth or tape imbedded between 2 coats of vapor barrier sealant. Point up other joints and breaks with hydraulic setting cement.

4. The completed installation shall form a smooth and neat appearance.

3.2 EXISTING INSULATION

A. Repair insulation damaged or disturbed during construction with approved, similar materials, installed to match existing. Install new jacket lapping and sealed over existing.

3.3 ACCESSORIES

A. Provide bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers recommended by insulation manufacturer for application indicated. Do not use staples. Provide adhesives, cements, sealers, mastics and protective finishes recommended by insulation manufacturer for application indicated.
3.4 OUTDOOR PROTECTION

A. All outdoor insulation shall be covered with a weather protective jacket consisting of 22 gage aluminum or 26 gage stainless steel protective covering. Edges of exterior jacket shall be securely closed around insulation to prevent rain, snow, dirt, etc. from damaging the underlying insulation in any fashion.

END OF SECTION 230713
1.1 DESCRIPTION OF WORK

A. Piping Insulation (Glass Fiber Type)

B. Piping Insulation (Flexible Foam Plastic Type)

1.2 RELATED DOCUMENTS

A. American Society for Testing and Materials

1. Flame Spread: 25 or less; ASTM E84, NFPA 255

2. Smoke Developed: 50 or less; ASTM E84, NFPA 255

1.3 QUALITY ASSURANCE

A. Insulation shall not be applied until all piping has been tested and approved and thoroughly cleaned. All insulation work shall present a neat appearance with smooth and uniform surfaces. Work done in a slovenly manner will not be acceptable. All insulation joints shall be carefully fitted and tightly butted. All jacket materials shall be neatly applied with smooth surfaces and shall be securely adhered or pasted in place. All seams and joints shall be located so that they are as inconspicuous as possible. Exposed edges and ends of all insulation shall be sealed and finished to provide a complete, unbroken vapor seal. The Contractor shall install insulation to be continuous through pipe sleeves.

B. Failure, due to faulty workmanship or material, of any portion of the installed insulation to perform the function as intended by these specifications, either stated or implied, for a period of one (1) year after acceptance of the project by the Owner, shall be the responsibility of the Contractor and shall be rectified at no additional cost to the Owner. This shall include the loosening of any jacket material, the appearance of condensation on the outside of the insulation, or any other mechanical or thermal failure which affects either appearance or efficiency of installation.

1.4 SUBMITTALS

A. Submit shop drawings for all insulating materials in accordance with Division 1, Section 013300.

B. Shop Drawings:

1. Submit shop drawings which indicate complete material data, mastics, adhesives, list of materials proposed for this project and indicate thickness of material for individual services.

C. Product Data:

1. Provide current manufacturer’s data to show compliance with these specifications and governing regulations; include proof of compliance for test products of products for fire and smoke rating, corrosiveness and compressive strength.
PART 2 - EQUIPMENT

2.1 PIPE INSULATION (GLASS FIBER TYPE)

A. Material – Pipe insulation including fittings and devices, unless specified otherwise, shall be insulated with 1-piece rigid molded glass fiber, 4 lbs/cu ft density with a K value of 0.22 at 75°F. The insulation shall be suitable for temperatures of –40° to 450°F, and with longitudinal flap, butt joint end strips and factory applied pressure sealing lap adhesive.

B. Manufacturers:
   1. Insulation:
      a. Certain-Teed: CSG Snap-On ASJ-SSL Products
      b. Knauf: Pipe Insulation
      c. Manville Corp.: J-M Micro-Lok, 650 APT
      d. Owens-Corning: One-Piece Fiberglass 25

   2. Fitting Covers:
      a. Certain-Teed: Snap-On Products
      b. Insul-Coustic: Insul-Sure Heavy Density Birma
      c. Manville Corp.: Zeston, One Piece Pre-molded
      d. PVC Cover with Fiberglass Insert.

2.2 PIPE INSULATION (FLEXIBLE FOAMED PLASTIC TYPE)

A. Material - Flexible foamed plastic insulation shall be vapor sealed pipe covering. Material shall be closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

B. Manufacturer:
   1. Armstrong: "Armaflex II".
   2. Certain-Teed
   3. Rubatex Corp.

2.3 PVC JACKETING

A. Provide PVC Jacketing on all pipe insulation located below the ceiling line in non-mechanical spaces. Areas include all manufacturing and process areas. Cover pipe fittings and other equipment from an outside diameter of 1-5/8" to 24" in accordance with ASTM C-585.

B. PVC jacketing material shall be gloss white outdoor and spray down weatherable. Fittings, unique shapes fit screwed, welded and flanged elbows, tees, valves, couplings, laterals, reducers and end caps. The Jacketing shall be .020" minimum thicknesses. The Jacketing and Fitting Covering Systems include solvent weld adhesives, stainless steel tack fasteners, silicone caulking and adhesive tapes. A die-cut multi-temperature fiberglass insulation insert is available and sized for a full insulation over the exposed pipe fitting and under the overlay of the PVC Fitting Cover.
1. Code Compliance: PVC Fitting Covers and Jacketing meet: Military Specification LP-1035A, Type 11 Grade GU and Type 111, and LP-535E, Type 11 Grade GU and Type 111. Federal Specification HH-I-558, Form B, Type 1 Class B. Requirements of USDA and FDA for use in facilities of the food processing, beverage and pharmaceutical industries. PVC jacketing 25/50 fire class per ASTM E-84. Thermal conductivity of 0.26 BTU/hr/sq ft/°F/In

2. The system shall have an applicable temperature range of -35°F to 500°F (-57°C to 260°C).

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Systems shall be completely covered throughout, including valves, fittings and accessories. Strainer covers and valve bonnets shall be accessible for maintenance. Unless specified otherwise, insulation shall extend continuous through sleeves. Where pipe covering terminates at ceilings, wall and equipment, furnish and install covering protector cups fastened to covering. Cups shall be Zeston polyvinyl chloride (PVC), or approved equal.

B. All adhesives, tape and any other material used for sealing shall be applied in strict accordance with manufacturer's instructions which includes covering rate of application, method of application, temperature limits for application of said materials, or any other condition affecting efficiency or permanence of the installation.

C. Where pipe hangers are present, insulated pipe shall be furnished with ribbed galvanized steel shields of not less than 18-gauge, two-piece pre-molded, high compressive strength, insulation inserts (360° around pipe), and vapor barrier jacket covering the insulation inserts. Inserts shall be constructed of high density, 100 psi, waterproofed calcium silicate, encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation.

D. Service access shall be provided through insulation where required. Insulation at flanged joints shall be designed to permit removal of flange bolts and nuts. Insulation for removable flanges of cold pipe strainers shall be fabricated with built-up sections of fiberglass pipe covering arranged to facilitate servicing of the strainer. Applications shall be complete with vapor seals.

3.2 PIPE INSULATION (GLASS FIBER)

A. Installation shall be in strict accordance with the manufacturer's instructions. Jacket shall have finish so as not to require field painting, but shall be suitable for field painting if desired.

B. Fittings, valves and accessories shall be insulated with PVC fitting covers with glass fiber inserts to provide same insulating values as the pipe insulation in locations where piping is exposed to view. Strainer covers and valve bonnets shall be accessible for maintenance. Fitting covers on "cold" pipe requiring vapor barrier jackets shall be installed vapor tight using adhesive and "Z"-tape applied to the circumferential joints, overlapping the fitting cover and adjacent insulation jacket. No tacks shall be used on vapor tight fitting covers.

C. Where piping is concealed by construction, the fittings, valves, and accessories shall be insulated with PVC covers as specified for exposed piping. Strainer covers and valve bonnets shall be accessible for maintenance.
D. **Use of staples is prohibited**, except staples may be used in the longitudinal joints. If after staples are installed, the entire longitudinal joint shall be covered with 3" wide adhesive backed strip to match insulation jacketing to cover staples and securely attached.

E. Piping to be insulated and thickness of insulation shall be as follows:

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Pipe Sizes</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating hot water supply &amp; return</td>
<td>Thru 2&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td></td>
<td>2½&quot; &amp; Larger</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>Chilled water supply &amp; return</td>
<td>All Sizes</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>Steam supply</td>
<td>All Sizes</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>Steam condensate</td>
<td>All Sizes</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

### 3.3 PIPE INSULATION (FLEXIBLE FOAMED PLASTIC)

A. Insulation shall be slipped on piping prior to installation as much as practical. Where this is not possible, insulation shall be carefully split, applied over pipe and sealed with approved vapor barrier mastic. Fittings, valves, and accessories shall be covered with cut and mitered sections of required size. Strainer covers and valve bonnets shall be accessible for maintenance. All joints shall be carefully made and completely sealed to maintain the integrity of the installation. Joints or seals improperly made will be rejected and they shall be repaired without additional cost to the Owner.

B. Piping to be insulated and thickness of insulation shall be as follows:

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Pipe Sizes</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerant hot gas and liquid lines</td>
<td>All Sizes</td>
<td>½&quot;</td>
</tr>
<tr>
<td>Refrigerant suction gas piping</td>
<td>All Sizes</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Condensate drainage piping</td>
<td>All Sizes</td>
<td>½&quot;</td>
</tr>
</tbody>
</table>

C. Where insulated pipes pass through floor, ceilings, and walls, and are exposed to view (not concealed by construction), the Contractor shall furnish and install cover (escutcheon) plates.

### 3.4 ACCESSORIES

A. Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers recommended by insulation manufacturer for application indicated. Do not use staples on cold water insulation. Provide adhesives, cements, sealers, mastics and protective finishes recommended by insulation manufacturer for application indicated.
3.5 OUTDOOR PROTECTION

A. All outdoor insulation shall be covered with a weather protective jacket consisting of 22 gage aluminum or 26 gage stainless steel protective covering. Edges of exterior jacket shall be securely closed around insulation to prevent rain, snow, dirt, etc. from damaging the underlying insulation in any fashion.
SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Complete system of automatic controls. System shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server (existing), and a web-based operator interface (existing).

B. Installation and interface with existing building automation system.

C. Control devices, components, wiring, and materials.

D. Assist in system validation of control systems, including device calibration, software validation and system wiring.

E. Instructions to Owner.

1.2 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following specification divisions or sections constitute related work:

   1. Division 01 - Administrative Requirements
   2. Section 23 05 00 - Common Work Results for HVAC
   3. Section 23 37 13 – HVAC Diffusers, Registers, and Grilles
   4. Section 23 74 13 – Packaged Outdoor Rooftop HVAC Equipment
   5. Section 23 74 33 – Dedicated Outdoor Air Energy Recovery Units
   6. Section 26 05 00 - Common Work Results for Electrical
   7. Section 26 05 23 – Control Wiring and Devices
   8. Section 26 09 23 – Lighting Control Devices
   9. Section 26 29 20 – Motor Starters
   10. Section 26 29 23 – Variable Frequency Drives
   11. Section 28 30 00 – Digital Addressable Fire Alarm Systems

1.3 SUBMITTALS

A. Product Data and Shop Drawings: Submit in accordance with General Requirements, Division 1 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2006 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and three 11” x 17” prints of each drawing. When manufacturer’s cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be
accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware
   a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer’s description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
      i. Direct digital controllers (controller panels)
      ii. Transducers and transmitters
      iii. Sensors (including accuracy data)
      iv. Actuators
      v. Valves
      vi. Relays and switches
      vii. Control panels
      viii. Power supplies
      ix. Batteries
      x. Operator interface equipment
      xi. Wiring
   c. Wiring diagrams and layouts for each control panel. Show termination numbers.
   d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software
   a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
   b. Manufacturer’s description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
      i. Central Processing Unit (CPU) or web server
      ii. Monitors
      iii. Keyboards
      iv. Power supplies
      v. Battery backups
      vi. Interface equipment between CPU or server and control panels
      vii. Operating System software
      viii. Operator interface software
      ix. Color graphic software
      x. Third-party software
   c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers’ model numbers and functions. Show interface wiring to control system.
   d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems
   a. Riser diagrams showing control network layout, communication protocol, and wire types.
b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.

c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems’ design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.

A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

d. A point list for each control system. List I/O points and software points specified in Section 23 09 93. Indicate alarmed and trended points.

4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.

5. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents of the documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11” x 17” prints.

2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Section 23 09 23 Article 3.17 (Control System Demonstration and Acceptance).


4. As-built versions of submittal product data.

5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

6. Operator’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.

7. Programming manual or set of 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.

8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.

10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended spare parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

C. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary, to meet Owner’s needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

D. Approved contractor must have a resident service office within a fifty mile radius of project site.

1.4 APPROVED CONTROL SYSTEM MANUFACTURERS

A. The following are approved control system suppliers, manufacturers, and product lines:

1. Manufacturer:
   a. Automated logic

B. The contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product lines unless use of multiple manufacturers is given prior approval.

C. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.5 SYSTEM PERFORMANCE

A. 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 PRM.

10. **Control Stability and Accuracy.** Control loops shall maintain measured variable at setpoint within tolerances listed in PRM.

### 1.6 CODES AND STANDARDS

**A.** Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities’ codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

1. **National Electric Code (NEC)**
2. **International Building Code (IBC)**
3. **International Mechanical Code (IMC)**

### 1.7 OWNERSHIP OF PROPRIETARY MATERIAL

**A.** Project specific software and documentation shall become Owner’s property. This includes but is not limited to:

1. **Graphics.**
2. **Record drawings.**
3. **Database.**
4. **Application programming code.**
5. **Documentation.**

### 1.8 WARRANTY

**A.** Warrant work as follows:

1. **Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance.** Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner’s warranty service request.
2. **Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up.** If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. **If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that**
control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.

4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner’s written authorization.

5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

PART 2 - EQUIPMENT

2.1 GENERAL

A. Furnish and install temperature control systems for control of heating, cooling, ventilating, dehumidification, humidification and exhaust systems with, sensors, controllers, relays, switches, local control cabinets all required accessories, all control wiring required for temperature control systems, as called for by drawings and specifications and as required for a complete operable control system.

B. Control systems shall be complete and effective in the highest degree and shall comprise all parts and mechanisms necessary for their successful operation. Systems shall be free from defects in workmanship and material and shall be guaranteed to operate as required to maintain specified conditions and functions. Any repairs, adjustments or replacements made necessary by such defects during the first full year from the time of acceptance of the project by the Owner shall be made by the Contractor and control manufacturer without charge to the Owner.

C. This project includes Air Handling units, chillers, VRF units, unit heaters, fan coil units, etc. Under this project Siemens Controls shall integrate the aforementioned systems into the existing building ALC system using BACNET over IP.

D. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 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. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

D. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device
connection shall allow communication with each controller on the internetwork as specified herein.

E. 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.

F. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. 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.

2. 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 2309.93. 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.

2.3 NAMEPLATES

A. As specified in Section 2305.53 provide plastic laminated nameplates with engraving on or adjacent to each controller, transmitter, indicator, valve and/or damper operator, relay, sensor, switch, regulator, panel gage and elsewhere as indicated on drawings. Name plates shall identify device and point name/type. Name plates for control devices shall be mounted adjacent to the device or control panel backplate using screws.

B. For each control loop and device furnish and install identification on loop wiring where it enters DDC and/or control panels and at its final termination at control device. Name identification tag shall indicate loop number identification as noted on DDC panel schedule and shop drawings. Nameplate shall be permanently attached to control signal (wire or tube) using standard wire ties or clear tape.

C. Provide nameplates for all controls, devices, actuators and equipment interfaced with the new BAS system regardless if equipment or device is new or existing.

2.4 CONTROL WIRING

A. In addition to Section 2305.00, the Contractor shall provide all control wiring, raceways, control panels and wiring devices needed for connections required for control systems. The wiring shall include the furnishing and installation of all wire, conduit, boxes, and all other necessary materials and devices required for a complete and operable installation. All materials and
installation shall comply with requirements as specified in Division 26, Electrical Work and with the National Electrical Code and all applicable state and city codes and regulations. All wire for circuitry above 25 volts shall be installed in conduit and all splices and connections shall be made in boxes or device or equipment enclosures. All electrical boxes installed to serve control systems shall be painted black for that control wiring can be easily identified.

B. All low voltage wiring (circuitry at 25 volts or less) in mechanical rooms, areas without ceilings, inaccessible ceilings (gyp board) and hazardous areas shall be installed in conduit. Low voltage wiring above lay-in ceilings will not require conduit but shall be plenum rated.

C. All splices and connections in low voltage wiring shall be made in boxes or approved device or equipment enclosures. All electrical boxes installed to served control systems shall be painted black for that control wiring can be easily identified.

D. Low voltage (25 volts and under) control wiring shall not be installed in the same conduit with higher voltage circuitry wiring. Where low voltage wiring enters the same box or enclosure with higher voltage wiring, dividers, and separation shall be provided to comply with codes and regulations, and as required preventing malfunctions in low voltage control. Where separation of conductors for certain functions or control is recommended by the equipment or system manufacturer, then the conductors for these functions or control shall be installed in conduit separate from other conductors, regardless of voltage differential.

2.5 ELECTRONIC SUBASSEMBLIES AND COMPONENTS

A. Plug-in assemblies shall be mechanically secured in place with captive fasteners and keyed for proper insertion.

B. Components shall be mounted for ease of replacement and maintenance after assembly. Controls and adjustments for maintenance personnel shall be separately located from those required by operation personnel, and shall be readily accessible.

C. Transducers and associated parts shall be constructed and installed in such a manner as to provide accessibility and adequate protection against mechanical damage, degradation of performance and contamination from the environment.

D. Device Requirements:

1. Push-button and selector switch operators; indicating (pilot) lights and similar devices shall be oil-tight, NEMA 12 construction minimum.
   a. Push-button operators shall retain their color identification throughout their life.
      The color code for push-buttons shall be as shown in Table 9-1(a).

2. Emergency push-button operators shall be of the palm or mushroom type.
   a. Palm or mushroom type buttons shall not be used in start circuits.
   b. "START" button operators shall be of the fully-guarded type.
   c. "STOP" button operators shall be of the unguarded type.
   d. The color code for pilot lights shall be as shown in Table 9-1(b).

3. Pilot lights shall be of the push-to-test type, powered by the device 120 Volt control circuits. A remote push-to-test circuit to test all pilot lights simultaneously may be used in lieu of individual push-to-test pilot lights. Pilot lights shall be as manufactured by Allen Bradley No. 800T-QT10R or equal Square D, General Electric, or Cutler Hammer.
a. Application of "push-to-test" lights or circuits shall be such that energization of any other part of the control circuit will not occur when the light is tested.

E. Touch type control devices shall not be used to perform operator control functions.

1. Operator Control Station Requirements:
   a. Fixed control stations shall be NEMA 1 construction minimum complete with metal enclosure and cover. Finishes on metal enclosures shall be as specified herebefore.
   b. All Push-button and pilot light enclosures providing for six or more units shall be equipped with piano hinged covers.
   c. Where six or more units are required, terminal strips shall be furnished in the enclosure.
   d. Spare space shall be provided for 25 percent additional push-buttons or pilot lights of the same size, with a minimum of two spaces.

2.6 DDC PANEL SCHEDULES

A. DDC panel schedules included within the appendix of these specifications are intended to show the minimum I/O requirements for this project. Schedules do not relieve the Contractor from furnishing additional I/O points devices are controls to accomplish the control strategies as indicated by the sequence of control for each system.

B. Spare point capacity indicated by DDC panels’ schedules represents the minimum spare point capacity of Binary Input/Output and Analog Input/Output points required at the completion of the project unless changed or deleted otherwise by contract change order.

2.7 APPLICATION SOFTWARE

A. The Contractor shall provide all application software and development including writing, loading and debugging as well as generation of all graphic displays for each HVAC system as specified herein.

B. All APPLICATION software shall be submitted to the Engineer for approval before loading into system. Before application software is allowed to take control of HVAC systems it shall be tested and validated by the Engineer as specified under Sections above. Under no circumstances shall the Contractor activate application software until all validation services have been completed.

2.8 BAS GRAPHICS

A. Contractor shall provide and generate all graphic displays as specified herein. All graphic displays shall be dynamic with color coded objects to indicate status of device. The manufacturer shall provide all initial generation of graphic displays for the building automation system. Graphic displays shall be required for each air handling system. Graphics shall provide current status, setpoints and values of all applicable I/O points.

B. The graphic generation software shall include a database of common HVAC library symbols for use in generating graphics pages.

C. Graphic displays shall include, but not limited to the following:
1. Floor plan maps of all buildings which show all heating and cooling zones, sensor locations, setpoints and values.
2. Space sensors (temperature, humidity and pressure)
3. Duct and unit mounted sensors.
4. Control dampers
5. Safety devices (freeze stats, smoke detectors)
7. Pumps
8. Coils
9. Air handling systems

D. Graphics pages shall be arranged in a multi-tiered fashion so that it shall be possible to move through a sequence of graphics from a higher level, floor plan map, to the next lower level, such as the mechanical system (AHU) graphic, etc.

E. Graphics shall display real time of any connected point in the BAS. System graphics shall display alarms, exceptions, diagnostics and the current status of alarms.

2.9 ALARM PROCESSING

A. BAS software shall report all alarms via the Operator Interface and shall also be automatically printed on the alarm printer; alarm information printed shall include the following:

1. Identification of equipment or systems
2. Current time and date
3. Day of the week
4. Point name
5. Alarm description, e.g., high temperature
6. Alarm point value or status
7. Appropriate engineering units

B. Alarms shall be operator definable and the alarms shall be stored in memory until operator acknowledged. To acknowledge an alarm and to clear the alarm status from memory shall require a coded entry via the keyboard, and once acknowledged, the printer shall print a acknowledgment including date and time of day. Alarms shall be acknowledged on a per point basis. Return to normal of points previously in alarm shall be logged including time, date, and user name of point. In the event of multiple alarms, all alarms shall be buffered according to priority until displayed or printed.

C. The system software shall be capable of enabling certain alarms to cause the system to automatically initiate a call to a remote system through the telephone network to issue an alarm report. This same software shall likewise allow access to a remote system for an alarm update or report upon command.

D. Each setpoint associated with an analog input point shall have associated high and low alarm limits. If the measured or calculated value falls below the low limit or exceeds the high limit, that point shall be considered in alarm and shall be reported as previously defined. Each high and low limit shall have an associated limit differential to prevent nuisance alarms caused from floating about the alarm limit.
E. For each binary contact alarm designated on the system, the user shall be able to define which contact state is the alarm state. Any binary point shall be disabled from alarm reporting if it is associated with a previously defined master point which is turned off. The user shall be able to define an adjustable time delay which disables alarm checking during starting and stopping of equipment.

2.10 CONTROLLERS

A. General. Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Section 23 09 23. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

B. BACnet.


3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

4. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

C. BACnet Communication.

1. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

2. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

3. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

4. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

5. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

6. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.
1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

4. Stand-Alone Operation. Each piece of equipment specified in Division 23 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

E. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

F. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator’s Terminal for the system.

G. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

H. Serviceability.

1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

I. Memory.

1. Controller memory shall support operating system, database, and programming requirements.

2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

J. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation
shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

K. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.11 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs or SAs.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs are not allowed on this project.

I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.12 TEMPERATURE SENSORS

A. All temperature sensors shall be resistance temperature detectors with platinum sensing elements having a resistance of 100 ohms or higher and at 32°F an accuracy of 0.5°F or better through the range of 40°F to 120°F. Sensors shall be vibration and corrosion resistant, encapsulated in epoxy, series 300 stainless steel, anodized aluminum or copper.

B. Pipe insertion type sensors for installation in water systems shall have extension element with bulb and insertion well. The Contractor is responsible for installation of wells, where not previously provided, in existing piping systems. The probe of the sensor shall be constructed of
stainless steel and sized to reach the end of the well. The well shall be constructed of stainless steel and sized to reach into the center of the pipe. Thermowell shall have variable extension for pipe insulation and threaded connection to pipe. Maximum length shall be 6” or ¾ of pipe diameter whichever is smaller. Pipes with small diameters shall have the well mounted at a 90° elbow to allow sufficient contact with the fluid. At the time of final installation of the probe ensure that the well is filled with a heat transfer compound. Sensors shall be removable without shutting down the system in which they are installed.

C. All temperature sensors with the exception of room sensors shall include transmitters to create a 4-20 ma control loop signal. Sensor control loop shall interface directly with DDC panels without the use of additional transducers or signal converters.

D. Manufacturers:
   1. Vaisala Inc.
   2. Rotronic
   3. Vaisala Inc.
   4. Verris
   5. Siemens

2.13 TEMPERATURE SENSORS & TRANSMITTERS (ROOM)

A. Room temperature sensors serving air handling units such as RTUs, ERVs, etc. shall be thermistor type, 10K, Type II.
   1. Sensors shall be provided with a direct interface with the Energy Management System using hand held tool (lap-top computer).
   2. Sensors shall include occupancy override to activate the occupied mode of the HVAC system during unoccupied periods.
   3. Sensors shall have ability to adjust temperature setpoint.
   4. Sensors shall have a display for showing room setpoint and room temperature.
   5. Sensors shall be provided with heavy duty clear lockable vandal resistant cover.

B. Manufacturers:
   1. BAPI
   2. Johnson Controls
   3. Mamac
   4. Siemens

2.14 HUMIDITY SENSORS

A. Space and duct humidity sensors shall be provided as shown on drawings, and shall be used for control of duct mounted steam humidifiers and alarms on high and low humidity limits in the space and supply ducts.

B. Humidity sensors shall be electronic. Pneumatic sensors are not acceptable. Space and duct sensors shall have a sensing range of 20% to 80% RH.

C. Duct sensors shall have a sampling chamber.
D. Outdoor air humidity sensors shall have a sensing range of 10% to 95% RH and shall be suitable for ambient conditions of -40°C to 75°C (-40°F to 170°F).

E. Humidity sensors shall not drift more than 1% of full scale annually.

2.15 PRESSURE INDEPENDENT CONTROL VALVES (VALES LESS THAN 2-INCHES)

A. Control valves shall be factory fabricated of nickel plated brass body, forged brass sensor housing, stainless steel ball and stem, Teflon PTFE seats, Tefzel characterizing disc, EPDM O-rings, and female NPT union ends. Valve shall be pressure independent. Valve body shall be rated for minimum 360 psi. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSID.

B. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic. The flow shall not vary more than +/- 5% due to system pressure fluctuations across the valve with a minimum of 5 PSID across the valve.

C. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base. The pressure independent valve shall have P/T ports to verify flow.

1. Valves shall have 2-way or 3-way pattern as detailed on drawings and shall be furnished for modulating function as specified by sequence of control.

D. Manufacturers:

1. Belimo
2. Flowcontrol Industries
3. Neptronics

2.16 CONTROL VALVES (LARGER THAN 2-INCHES)

A. Control valves shall have cast iron bodies, stainless steel ball and stem, Teflon PTFE seats, EPDM O-rings, stainless steel characterizing disc, adjustable springs for sequencing of operation, and threaded, flanged, or grooved connections as required. Furnish positioning relays if required to obtain the sequence action for the required control function. Valves shall provide tight shut-off. Valves shall be rated for not less than the working pressure and temperature of the system in which they are installed, minimum pressure rating of ANSI 125, Class B.

1. Valves shall have 2-way pattern as detailed on drawings and shall be furnished for modulating function as specified by sequence of control.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
   a. Water Valves:
      i. Two-way: 150% of total system (pump) head.
      ii. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

B. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic. The flow shall not vary more than +/- 5% due to system pressure fluctuations across the valve with a minimum of 5 PSID across the valve.
C. Water Valves shall fail normally open or closed, as scheduled on plans, or as follows:
   1. Water zone valves – normally open preferred.
   2. Heating coils in air handlers – normally open.
   3. Chilled water control valves – normally closed.
   4. Other applications – as scheduled or required by sequences of operation.

D. Manufacturers:
   1. Belimo
   2. Siemens
   3. Honeywell
   4. Johnson Controls, Inc.

2.17 ELECTRIC ACTUATORS

A. Provide electric actuators for control dampers, control valves smaller than 3” and elsewhere as indicated on drawings.

B. Electric actuators shall be direct-coupled type. Damper actuators shall be mounted directly to the damper shaft without the need for connecting linkage. Actuators shall include electronic overload or digital rotation sensing circuitry to prevent damage to the actuators throughout the entire rotation of the actuator.

C. Actuators serving outdoor air dampers, chilled water control valves and cross-over dampers, air handling unit discharge dampers and elsewhere as shown on drawings shall have spring return mechanism built in into the actuator housing.
   1. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simple changing the mounting orientation.
   2. Actuators shall have an arrow identification indication the position of actuator.
   3. Actuator exposed to the outdoors shall be provided with 304 stainless steel housing with a neoprene gasketed door. Housing shall have a NEMA 4X ratting and suitable for outdoor installation.

D. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control input signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators capable of accepting a pulse width modulating control signal and providing full proportional operation are acceptable.
   1. All actuators shall provide a 2 to 10 VDC position feedback signal.
   2. All modulating actuators shall have an external, built-in switch to all the reversing of direction rotation.
   3. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuators rated torque.
   4. All non-spring return actuators shall have an external manual gear release to allow manual positioning when the actuator is not powered. Spring return dampers with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.

E. Wiring: 24 VAC and 24 VDC actuators shall operate on Class 2 wiring.
F. 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.

G. Manufacturers
   1. Belimo
   2. Alerton
   3. Automated Logic

2.18 DUCT MOUNTED SMOKE DETECTORS

A. Provide duct mounted smoke detectors for the Kitchen and Surgery Air handling Units. Smoke detector shall be hard wired into the units safety circuit along with freeze stat and shall shutdown unit regardless of mode of operation (automatic or manual).

   1. Coordinate wire termination location with Division 26 contractor and variable speed drive supplier.
   2. Provide a relay for when smoke detector trips the BAS system detects unit went down on smoke detection shutdown. Report alarm as noted in sequence of operations

B. Detector shall be furnished with sample tube having an insect screen to minimize nuisance alarms and shall be designed to ignore invisible airborne particles or smoke densities below factory setpoint. Sampling tube shall be securely mounted and attached at both ends.

C. The detector electronics shall be immune to false alarms cased by EMI or RFI.

D. Provide two single pole double throw alarm relay contacts for each detector.

E. Provide duct-type detector in both the supply and return connection for all air handling equipment greater than 2,000 CFM.

2.19 CURRENT SWITCHES

A. As an option to the Contractor current switches can be used for fans and pumps for flow status indication to Building Control System. Current switches shall be designed and rated for the maximum amp draw of the device being monitored.

B. Current switches shall indicate the presence of electrical power by monitoring the amps of the conductor feeding motor of the fan or pump. The control range for the device shall be such that the failure of belts on a belt driven fan shall indicate an alarm.

2.20 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall have sensors on inlet and outlet side of fans and pumps for flow status indication to BAS. Differential pressure switches shall be designed and rated for the maximum pressure range and shall be adjustable at the device.

B. Differential pressure switches for air and gas systems shall be diaphragm operated with 4" diaphragm to actuate a SPDT snap switch. Motion of diaphragm shall be restrained by a
calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated. Motion of the diaphragm shall be transmitted to the switch button by means of direct mechanical linkage.

C. Differential pressure switches for water or liquid shall be operated by two opposing bellows of type 316 stainless steel. Bellows shall actuate SPDT snap acting switch via direct mechanical linkage. High and low pressure setpoints shall be visible and externally adjustable.

2.21 STATIC PRESSURE TRANSMITTERS

A. All pressure transmitters for sensing static pressure in ductwork, fan discharge and space as specified herein shall be of the electronic type and provide an output signal of 4 to 20 mA. Pressure sensors shall include multiple sensing ports, pressure impulse suppression chamber of at least 50 in³, airflow shielding and ¼” compression takeoff fitting, all contained in a welded steel casing.

B. Pressure transmitters shall provide a signal to the duct static pressure controllers. Pressure transmitters shall have an accuracy of ± 1% of full scale or better and a repeatability of 0.3% of full scale or better. The effect of ambient temperature variations shall be less than .033% of full scale for ambient temperature changes from 40°F to 100°F when calibrated at 70°F.

C. Manufacturers:
   1. Setra
   2. Air Monitor Corp.
   3. Dwyer Series 607

2.22 CONTROL PANELS

A. An individual control panel of standard design shall be provided for each control system as shown or plans and as required by control sequences.

B. Panel enclosures shall be constructed of black steel not lighter than 16-gauge with turned edges and shall conform to requirements of NEMA 12. At Contractor’s option, panels may be constructed of aluminum not lighter than 12-gauge. The exterior door of panel shall be equipped with a latch and lock.

C. Panels shall be factory-pre-piped to bulkhead fittings and pre-wired to numbered terminal strips. Contractor shall provide wiring diagram which shall indicate function of each monitoring point numbered on the terminal strip. Contractor shall provide wiring diagram correlated to numbered terminal strip which shall indicate monitoring capability from Central Building Management System.

D. Each control panel will include all switches, meters and other devices necessary to provide the diagnostic features indicated by the Panel Layout. For panels which provide pneumatic outputs, the outputs shall be displayed on pressure gauges of at least 2-1/2 inches diameter and an accuracy of 5% of full scale or better. Where indicated on the drawings, panels shall include analog electronic voltmeters to indicate the position of pneumatic operators and other control devices as indicated. The analog voltmeters shall be at least 2-1/2 inches in diameter and provide an accuracy of 5% of full scale or better.
2.23 FREEZE STATS

A. Provide unit mounted freeze stats for all new rooftop air handling units and energy recovery units. Freeze stats shall be hard wired into the units safety circuit along with smoke detector and shall shutdown unit regardless of mode of operation (automatic or manual).

1. Coordinate wire termination location with Division 26 contractor and variable speed drive supplier.

B. Temperature sensors used for freeze protection shall have 20 foot elements (not averaging type) installed to serpentine the entire coil face area. Where coils are two banks, two low limit sensors wired in series shall be provided.

C. Freeze protection stats shall include 2 sets of normally closed contacts. One set of contacts shall be wired directly into motor control circuit and one shall be used for remote monitoring through the building BAS.

D. Manufacturers:
   1. Honeywell
   2. Johnson Controls, Inc.

2.24 ANCILLARY DEVICES, EQUIPMENT AND CONTROL PANELS

A. All electromechanical control equipment shall be housed in a control panel.

B. Screw-type terminals with captive saddle straps or equivalent means of retaining stranded conductors shall be provided on control devices and terminal strips.

C. Control devices shall be identified in accordance with requirements as specified in Section 17195.

D. The mounting details of all control devices shall not be modified from the manufacturer's standard mounting dimensions and practices.

E. Plug-in devices and assemblies shall be mechanically secured.

F. Wiring Duct

1. Wiring duct shall be used to enclose panel wiring as required to provide the appearance of good workmanship. Duct shall be Panduit Corporation - Type E or equal. The wire duct color shall be the same throughout the panel. The duct shall be securely fastened to the panel with screws and washers or rivets. Ducts shall be a maximum of 75 percent full.

2. Wiring within digital and ancillary control panels shall be routed by duct wherever possible. Wire shall be neatly and symmetrically arranged within the control cabinet.

3. Wiring ducts shall be provided from the entry point of external cable to the termination point of the cables. The AC and DC wiring leading from the devices and terminal blocks to the field shall be formed to exit separately in dedicated areas on the top and/or bottom of the panel.

4. All wiring to door-mounted devices shall be suitably looped, protected with spiral wrap, and secured with "Ty-Rap" with adhesive mounting bases (for door mounted devices only).
G. Terminal blocks

1. Terminal blocks shall be arranged for vertical conduit entry. Terminal blocks shall have no more than two wires connected per termination point. Factory jumpers may be used where required. Terminal blocks shall be of the insulated, channel-mount type with screwed tubular connectors. Provide mounting rails.

2. All terminals shall be numbered with a permanent, nonconductive strip on each block according to the detailed wiring drawings. Provide mounting track to anchor terminal blocks to control panel.

3. Terminal blocks shall be Weidmuller medium duty, 300-volt, Model WDU4 or approved equal.

4. All wiring entering and leaving control panels shall be terminated on a numbered terminal strip.

H. Control Relays

1. Control relays shall be UL listed and enclosed in a dust proof enclosure, four-pole minimum, eight-pole installed maximum, unless noted or indicated otherwise on the drawings. Relays shall have a complete set of contacts (e.g., a four-pole block shall have all contacts furnished).
   a. Control relays shall be provided with track mounted socket and mounting tracks.
   b. Control relays shall be rated for the intended purpose.
   c. Control relays shall be provided with non-incandescent, mechanical, neon or LED indicators that illuminate or change position to indicate that the coil is energized.

I. Circuit breakers

1. Circuit breakers shall be track mounted, 250V, with continuous duty ampacity rating indicated on the drawings. Breakers shall have a maximum interrupting capacity of 200 Amps but not exceeding 100 times rated current. Operating life shall be a minimum 6,000 cycles at rated current and 4,000 cycles at 200% rated current and minimum dielectric strength of 1,500 Volts AC, mounting track must be provided.

J. Power Supplies and transformers

1. Provide factory-assembled, general-purpose, ventilated, dry-type distribution transformers of rated kVA capacities required.

2. Transformer shall be rated for continuous operation, at rated kVA, without exceeding a total winding temperature, as indicated below:

3. Insulation System Classification

4. Mount transformers and power supplies within NEMA control panels as specified below. Transformer shall be electrically grounded to enclosure by means of a flexible metal grounding strap.

5. Do not exceed maximum NEMA sound-levels as follows:
   a. 0 - 50 kVA 45db
   b. 51 - 150 kVA 50db
   c. 151 - 300 kVA 55db
   d. 301 - 500 kVA 60db
   e. 501 - 700 kVA 62db
   f. 701 - 1000 kVA 64db
6. An electrostatic shield shall be placed between the primary and secondary windings.
7. Provide engraved laminated plastic equipment/system identification nameplates complying with Section 15195.
8. All transformers and power supplies shall include fusing on both the primary and secondary. In addition, provide disconnecting means for servicing and replacement.

K. PROTECTION

1. All protective devices shall be selected and applied with proper consideration of the inrush and normal operating current of the load as well as the thermal capacity and the short circuit with interrupting capability of the series connected devices and any equipment being protected by the device.
   a. Two or more protective devices applied in series shall be selected with proper time-current and let-through energy characteristics to provide as much selective circuit protection for fault and overload conditions as possible, based on the manufacturer's data.
   b. Time delay fuses shall be applied for current limiting, as well as, protection from nuisance blowing caused by inrush currents.
   c. Current-limiting fuses shall be applied where the available short circuit current approaches or exceeds the momentary withstand and the interrupting capacity of the standard protective equipment.
2. Fuses for control wiring shall be time delay (dual element) types having a minimum interrupting rating of 120 percent of the maximum available system short circuit current. In no case shall the interrupting rating be less than 100,000 amperes rms. symmetrical.
   a. All low voltage fuses shall be high interrupting capacity (energy limiting) and Underwriters' Laboratories listed and labeled as specified hereinafter.
3. Control conductors shall be protected against short circuits and steady over loads. An overcurrent device shall be connected in series with each ungrounded leg of all branch control circuits.
   a. The overcurrent device rating shall be as low as practical and shall not exceed values specified in the following table for the smallest conductor in the branch circuit.
   b. The control transformer and power supplies shall be protected in the primary and secondary circuits against short circuits and overloads as specified in the following table.
4. Note:
   a. For transformers larger than 5000 volt-amperes, the protective device rating shall be based on 125 percent of the secondary current rating of the transformer.
   b. For primary fuse requirements, refer to NEC Section 450.

5. Each solenoid shall be considered as a separate branch circuit and shall have an overcurrent device rated at approximately 150 percent of the sealed solenoid current. The overcurrent device shall be connected between the solenoid and the control relay contact or output device. If a fuse is used, then it shall be a dual element indicating type.

6. Under voltage protection shall be provided on all equipment which may be damaged by a continuous under voltage condition or which may initiate motion upon return of power after an under voltage condition.

L. CONTROL PANELS

1. Control panels exposed to outdoor weather and panels located indoors positioned under or within three feet of water or steam lines shall have a NEMA 3R designation. All other control panels shall have a NEMA 1 designation unless noted otherwise on drawings.
   a. Unless noted otherwise all control panels located in mechanical rooms and designated control rooms (or areas).

2. Control panels shall be provided DDC equipment, relays, transducers, switches, pneumatic devices, terminal blocks and other miscellaneous control devices that are not field mounted.

3. Panels shall have hinged doors and keyed lock. All control panels shall be keyed the same including Digital Control Panels. All control panels shall be shop painted with manufacturers standard finishes and colors.

4. Provide UL-listed cabinets for use with line voltage devices.

PART 3 - EXECUTION

3.1 CONTROL CIRCUITS

A. Circuits serving control systems shall be engineered to prevent a single point of failure in the operation of the mechanical systems serving the facility. Digital Controllers shall be sub-divided so that in the event of a single panel failure the redundant system will not be affected including its power source.

B. The guideline that shall be used to determine circuiting for DDC controls is as follows:

1. DDC panels shall have a means to disconnect its power source to replace transformer without effecting remaining controllers served from the same circuit.

C. Where rooftop air handling units are not provided with factory installed microprocessor controllers, they shall be provided with DDC controllers. Each rooftop air handling unit or energy recovery unit shall include a transformer to power the Digital Controller. Combining unit controllers using centrally located transformers and power supplies will not be permitted.
1. RTU/ERV controllers shall be housed in a NEMA 1 enclosure with hinged access doors to prevent accidental dropping of screws when gaining access to the controller.
2. The Control Contractor shall be responsible for providing hinged access doors for terminal unit digital controllers even if the terminal unit manufacturer at their factory installs the digital controls.
3. RTU/ERV enclosure shall house controller, transformer, fuses and auxiliary devices such as relays, terminal blocks and air sensing tubing.
4. Provide a disconnect switch on the side of enclosure for disconnecting power to the controller for service and replacement.

D. All transformers shall have a minimum of 25% spare capacity.

3.2 CONTROL PANELS

A. Control panels shall be installed to house control devices and components and shall meet the NEMA rating requirements specified above.

B. Each control panel will include disconnecting means so that the control panel can be de-energized without effecting adjacent controllers and control panels.

C. Control panels for Digital Controllers and ancillary control devices shall be engineered and designed in a neat and workman like manor. All wiring shall be installed in a Panduit (or equal) system. Panduit layout and design shall be such that exposed wiring is limited to three inches in length.

D. Digital Control Panels shall be installed in NEMA rated enclosures and shall meet all the requirements of this Section of the specifications.

3.3 RELAYS AND CONTACTS

A. Contact Rating:

1. Contacts on any starter, contactor or relay shall not be used in excess of its rating. Contacts shall not be connected in parallel to increase ampacity.

B. Interlocking between equipment shall be provided as indicated on drawings and as required to meet the intent of the control sequences specified within this Division of the specifications.

1. Interlocks between control circuits that are not de-energized by the same disconnecting means shall have isolated contacts, and shall be labeled as such.
2. Interlocks shall be provided as indicated on drawings and as required to meet the intent of the control sequences specified within this Division of the specifications.
3. Interlocks between control circuits that are not de-energized by the same disconnecting means shall have isolated contacts, and shall be labeled as such.

C. Isolation relays are required for all motors regardless of size. Digital controllers shall not be connected directly to starting equipment without the use of an isolation relay.

1. If relays are installed in the same enclosure as Digital Controllers provide numbered terminal strips for all wiring connections as specified above under Control Panels.
3.4 LOCATION AND MOUNTING OF CONTROLS

A. Components shall be mounted to provide mechanical clearances sufficient for mounting, wiring, adjustment, testing and replacement. Each component shall be mounted to provide heat dissipation consistent with the temperature rating of the component, adjacent components and conductors. Each component shall be arranged and oriented so that the identification may be determined without moving the component or its wiring.

1. Equipment shall be mounted so that any component or component part can be replaced without removing the subplate. No components shall be mounted behind door pillars unless adequate space is provided for replacement and servicing.
2. Control components shall be front mounted on a rigid metal subplate so that the complete subplate can be removed through the enclosure opening. Subplate metal shall be a minimum of 0.106 inch (MGS No. 12) nominal for mounting components with one-quarter inch diameter screws or smaller.
3. The bottom of the subplate-mounted device including terminal blocks shall not be less than 18 inches above the floor line. In no case shall the top of subplate mounted components be more than 84 inches above the floor line.
4. A minimum of 1 inch shall be provided between the subplate components and the sides of the enclosure for proper terminal wiring and maintenance access.
5. Subplate mounted control components shall be grouped together in one enclosure or compartment wherever possible.
6. Any component(s) mounted on the subplate carrying line voltage or a combination of line voltage and control voltage shall be grouped and segregated from devices that carry only the control voltage.
7. To minimize electromagnetic interference, solid state control and its associated wiring shall be segregated from the electromagnetic control wiring.
8. Subplate mounted control components, such as relays, starters and contactors shall be mounted in numerical order from left to right and top to bottom.
9. Terminal blocks located in compartments shall not be recessed more than 4 inches from the equipment surface. Terminal blocks shall be mounted to provide an unobstructed access to the terminals and their conductors. The blocks shall not be mounted above each other in a plane perpendicular to the subplate. Terminal strips shall not be mounted in wireways.
10. Separately mounted terminal strips shall be used for power circuits and control circuits in all enclosures. Terminal blocks shall be furnished in quantity as required for the specific installation.
11. Ten-percent spare terminals shall be provided on each subplate of every electrical enclosure and compartment. A minimum of eight spare control terminals and three spare power terminals shall be provided.

B. Mounting for electronic subassemblies and components shall be as follows:

1. Plug-in assemblies shall be mechanically secured in place with captive fasteners and keyed for proper insertion.
2. Components shall be mounted for ease of replacement and maintenance after assembly. Controls and adjustments for maintenance personnel shall be readily accessible and shall be separately located from those required by operating personnel.
3. Transducers and associated parts shall be constructed and installed in such a manner as to provide accessibility and adequate protection against mechanical damage, degradation of performance and contamination from the environment.
3.5 INSTALLATION

A. Locate controls, relays, instruments, switches, valves, devices and accessories so they are readily accessible for adjustment, service and replacement, and as indicated on the drawings. Where a conflict exists, verify final installation location with the Engineer.

B. Install control valves with power unit up.

C. Install all sensing elements with integral transmitters with a union located between the sensor and transmitter to permit easy disassembly of the unit and removal for service. All final electrical connections to transmitters shall be made with watertight flexible conduit, 3'-0" minimum length to permit handling during calibration and servicing.

D. Insulated surfaces:
   1. Where insulation on piping or equipment is punctured or penetrated due to installation of sensing elements or tubing, re-seal openings air and vapor tight. Leave all portions of sensors or transmitters that must be accessible for service or maintenance exposed.
   2. Where control devices are located on insulated surfaces, provide brackets to clear finished surface of insulation avoiding punctures of vapor seal.

E. Limitations:
   1. Locate, support, enclose and install control devices and equipment so as not to subject them to vibration, excessive temperatures, dirt, moisture or other harmful effects or conditions beyond their rated limitations.
   2. If devices must be located subject to conditions beyond their recommended or rated limitations, provide necessary protective enclosures and/or furnish equipment constructed of materials and features capable of withstanding adverse conditions.

F. Control valves:
   1. Install control valve operators to insure smooth positioning under load through full ranges and strokes indicated in both directions without binding or fluttering. Actuators shall be capable of holding steady in any intermediate or extreme position while respective systems are functioning at design flows, temperature and pressures.

3.6 TEMPERATURE SENSORS

A. Temperature sensors shall be located to sense appropriate conditions and where they are easy to access for service without special tools.
   1. Room temperature sensors shall be located on interior walls to average room temperature conditions. Avoid locations, which may be covered by office furniture. Sensors shall be mounted with centerline approximately five (5) feet above finished floor.
   2. Duct temperature sensors shall be located in the ductwork to accurately sense appropriate air temperatures. Do not locate sensors in dead air spaces or positions obstructed by ducts or equipment. Install gaskets between the sensor housing and the duct wall. Duct averaging sensors located between rigid supports shall be thermally isolated from the supports. Freeze protection sensors shall be located to sense lowest temperatures and to avoid potential problems with air stratification.
3. Immersion temperature sensors used to measure liquid temperatures shall have wells located to measure continuous flow conditions. Extension couplings shall not be used for thermowell installation. Sensors shall be removable without shutting down the system in which they are installed.

4. Outside air temperature sensors shall be located away from exhaust hoods, air intakes, and other areas that may affect temperature readings. Provide sunshields to protect sensors from the direct sunlight.
   a. Sensors exposed to the outdoors shall be installed in weather tight enclosures equivalent to NEMA 3R rating.

5. Freeze stats shall be provided for each fan system individually. Do not use a single freeze stat to control more than one fan.

3.7 PRESSURE SENSORS

A. Pressure sensing tips shall be installed in locations to sense appropriate pressure conditions. Duct static pressure sensors shall have high-pressure port connected to a metal static pressure probe inserted into the duct pointing upstream. The low-pressure probe shall be open to the plenum area at the point where the high-pressure probe is tapped into the duct. For building pressure sensors, the high-pressure port shall be inserted into the space via a metal tube and the low-pressure probe shall be piped to the outside of the building.

B. Provide shut-off valves in sensing lines serving DP switches in water and liquid systems. Shut-off service shall allow removal of the flow element from the process line without interruption of service.

C. Provide needle valves and bypass line in piping serving differential pressure transmitters for pressure equalization during startup. Needle valves shall be installed in accordance with the manufacturers written instructions. At a minimum, needle valves shall allow removal of the flow element from the process line without interruption of service and provide equal pressure to both the inlet and outlet of the transmitter during startup.

D. Provide capped test plugs (Pete's plug) in piping systems serving DP switches, and transmitters serving water and liquid systems. Provide plugs at both the inlet and outlet of switch or transmitter.

1. Plugs shall have a ¼" NPT brass fitting with Nordel valve core seals rated up to 1000 psi at -40°F and 275°F and shall allow insertion of a pressure or temperature probe while the pipe or equipment is under pressure. Plug fitting shall have a threaded brass cap.

3.8 INSTRUCTIONS TO OWNER & SYSTEM TRAINING

A. The Contractor shall submit a detailed proposed training plan to the Engineer and Owner for review and approval before commencement of training. Training plan shall outline all training sessions’ content and duration.

B. Training manuals (minimum of 8 required) shall be provided in loose leaf binders and shall include all necessary documentation for Host computer operation, DDC panel operation and Maintenance data.

C. The Contractor shall provide a minimum of 24 labor hours of training to the owner's staff on the operation of the control systems installed. Training may be spread out over a period of several
days to accommodate owner’s staff requirements. Formal training shall be provided once system installation is complete and prior to acceptance of the system by Owner. Training shall include but not limited to the following:

1. Owner personnel shall participate during the installation, software generation, system validation, system commissioning and start-up of the BAS.
2. Owner training shall be provided on a formalized basis and as an integral task within project contract requirements. Training at a minimum shall be divided into four separate categories as follows:
   a. Host computer and operator workstation training
   b. DDC panel operation, trouble shooting and maintenance
   c. Loop control, tuning and control device calibration
3. For each typical control loop instruct the owner on operation and calibration of each device. Document proportional and integral settings for each PID loop and instruct Owner’s staff on calibration adjustments and trouble shooting of electronic control systems.
4. Instruct owner on operation and maintenance for each control device and demonstrate calibration technique.
5. Contractor shall provide Owner training on I/O point definition, software strategy, system backup procedures and system down loading procedure.
6. Contractor shall provide Owner training on the operation and usage of the Host Computer system. Training shall include explanation of all required DOS commands as well as system software commands. Training shall include hardware operation, peripheral devices and components, report generation, software modification techniques and graphic generation and modification techniques.
7. Owner training shall include operation and function of LAN system used for communication between DDC panels and host computer systems.

END OF SECTION
1.1 DESCRIPTION OF WORK

A. HVAC Control Sequences described herein indicate the manner and chronological sequence in which, and methods by which, automatic, temperature controls function.

B. The BAS control system installed under this project shall be programmed to provide the intent of the sequences described herein. The BAS shall be furnished and installed complete and shall be properly adjusted and programmed to perform all sequences, functions, and status indications for all equipment and systems as herein specified and as indicated on drawings and as required by existing conditions.

PART 2 - CONTROL SEQUENCE

2.1 HEATING HOT WATER PLANT (DHWP-1, DHWP-2, DHWP-3, RP-1)

A. General System Operation

1. The Heating Hot Water Plant is comprised of two Domestic Hot Water Pumps (DHWP-1 & DHWP-2), and a variable speed package pumping system for heating hot water distribution and recirculation pump RP-1.

B. Heating Hot Water Plant Modes of Operation:

1. System Scheduling - The Heating Hot Water Plant control algorithms shall employ advanced schedule/calendar architecture to facilitate scheduled occupied/unoccupied modes of operation. The schedule/calendar shall provide the ability to setup diverse schedules of operation based on special events, holidays, and normal operation.

2. Occupied Mode: While operating in the occupied mode and the Heating Hot Water Plant is allowed to operate, the plant will be continuously enabled and controlling to maintain the leaving hot water temperature at the desired setpoint.

3. Unoccupied Mode: While operating in the unoccupied mode if any Air Handling Unit served by the Heating Hot Water Plant begins operation in the unoccupied mode, the Heating Hot Water Plant is allowed to operate, and the running unit requires heating hot water the plant shall enable.

2.2 AIR HANDLING UNITS (VAV)

A. Provide air-handling unit Sequence of Operation in accordance with the following written sequences.

B. Unit Description

1. The Air Handling Units are configured with ECM supply fans, chilled water coil, pre-heat coil and economizer capabilities. The units feed conditioned air to terminal units located throughout the air distribution ductwork.
C. AHU Modes of Operation

1. System Scheduling - The Air Handling Unit control algorithms shall employ advanced schedule/calendar architecture to facilitate scheduled occupied/unoccupied modes of operation. The schedule/calendar shall provide the ability to setup up diverse schedules of operation based on special events, holidays, and normal operation.

2. Occupied Mode: While operating in the occupied mode the unit will be continuously enabled and controlling to maintain the supply air temperature at the desired setpoint.

3. Unoccupied Mode: While operating in the unoccupied mode the unit will stage on/off based upon any zone rising above the unoccupied cooling setpoint. The unit will remain enabled until all zones are below the unoccupied cooling setpoint with a 2 degree dead-band. All terminal units served by the Air Handling Unit are Fan Powered Boxes. During unoccupied heating the Air Handling Unit shall remain off and space unoccupied heating shall be controlled strictly by the Fan Powered Boxes. Unoccupied space temperature setpoints are:
   a. Unoccupied Space Cooling Setpoint = 78 Degrees (Adj.)
   b. Unoccupied Space Heating Setpoint = 65 Degrees (Adj.)

4. Economizer Mode: The unit is allowed to operate in the economizer mode when the outside air enthalpy is less than 23 BTU/lb. When the outside air enthalpy is greater than or equal to 23 BTU/lb economizer mode is disabled and the mixed air dampers shall modulate to the minimum position.

D. Sequence of Operation – Unit Initialization:

1. Upon a unit initiation command if all safeties are in the “Normal Position” the supply fan shall be enabled and shall modulate to its minimum speed. Once enabled if the unit is not in the economizer mode the mixed air damper shall command to an adjustable minimum position.

2. Unit safeties include a unit mounted freeze stat and a return air duct mounted smoke detector. Unit safeties shall be hardwire interlocked with the supply fan starter. In addition safeties shall be monitored and alarmed by the BAS. If either of the safeties goes off the unit shall fully disable and the mixed air dampers and control valves shall go to their normal positions.

3. If at any point the supply fan command is enabled and supply fan status is false the unit shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

E. Sequence of Operation – Supply Fan Modulation:

1. Supply Air Duct Static Pressure (SADP) Setpoint Control: The SADP setpoint shall be calculated based upon using a reset table. The Reset Table calculates the SADP setpoint based upon the average terminal load from the terminal units. The supply fan ECM motors shall modulate to maintain the calculated SADP setpoint. Reference the following for reset table details:
   a. Terminal Load is defined as a percentage. Terminal Load = (terminal unit airflow cfm/maximum occupied cfm setpoint) x 100.
   b. SADP Setpoint Table Average Terminal Load Reset:

<table>
<thead>
<tr>
<th>Terminal Load % Cooling</th>
<th>SADP Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Value 90% (Adj.)</td>
<td>1.5 inwc (Adj.)</td>
</tr>
<tr>
<td>Low Value 40% (Adj.)</td>
<td>.85 inwc (Adj.)</td>
</tr>
</tbody>
</table>

F. Sequence of Operation – Chilled Water Coil:
1. Supply Air Temperature (SAT) Setpoint Control: The SAT setpoint shall be calculated based upon using the minimum value from two separate reset tables. Reset Table #1 calculates the SAT setpoint based upon an outside air temperature reset. Reset Table #2 calculates the SAT setpoint based upon the maximum space temperature measured in any of the units control zones. The ultimate SAT setpoint is the minimum output of these two values. Reference the following for reset table details:
   a. SAT Setpoint Table #1 Outside Air Temperature Reset:
      
      | OAT        | SAT Setpoint |
      |------------|--------------|
      | High Value | 85 Degrees (Adj.) | 55 Degrees (Adj.) |
      | Low Value  | 50 Degrees (Adj.) | 65 Degrees (Adj.) |

   b. SAT Setpoint Table #2 Max Zone Temperature Reset:
      
      | Max Zn Temperature | SAT Setpoint |
      |--------------------|--------------|
      | High Value         | 74 Degrees (Adj.) | 55 Degrees (Adj.) |
      | Low Value          | 68 Degrees (Adj.) | 65 Degrees (Adj.) |

2. The Chilled Water Valve shall modulate to maintain the cold deck at the calculated CDT setpoint if cooling is available. Cooling is available anytime the chilled water plant is providing chilled water.

G. Sequence of Operation – Dehumidification Control:

1. Whenever the monitored return air humidity value rises above the dehumidification setpoint of 50% (Adj.) and cooling is available the chilled water control sequence shall be overridden to control as follows.
   a. When in the dehumidification mode the chilled water control valve shall modulate to maintain a cold deck leaving air temperature of 55 Degrees (Adj.).
   b. Terminal box hot water control valves shall modulate to maintain the calculated SAT setpoint.
   c. The control system algorithm shall employ a 5% (Adj.) dead-band for dehumidification mode enable/disable logic.

H. Sequence of Operation – Morning Warm-Up Control:

1. When the unit switches from Unoccupied to Occupied, as programmed in the occupancy schedule, the controls shall perform the following sequence of controls.
   a. During morning warm-up the economizer dampers shall be controlled to 100% return air.
   b. The terminal units associated with this unit shall have their controls overridden to control the primary air to the max cooling cfm, and zone heating shall be locked out.
   c. The unit controls shall be locked out for a period of 5-minutes (Adj.). During this time period the unit shall circulate return air from the space.
   d. After the 5-minute lockout period has ended the unit controls shall compare the return air temperature with the average terminal unit occupied heating setpoint.
   e. If the return air temperature is less than the average terminal unit occupied heating setpoint then the re-heat control valve shall control to maintain the return air temperature at the average terminal unit occupied heating setpoint + 1.5 Degrees (Adj.). Once the return air temperature has reached the morning warm-up setpoint (average terminal unit occupied heating setpoint + 1.5 Degrees) the unit shall switch to normal operation.
   f. If, after the 5-minute lockout period the return air temperature is greater than the average terminal unit occupied heating setpoint then the unit shall switch to normal operation.
I. Sequence of Operation – Economizer Control:

1. While operating in the economizer mode the mixed air dampers shall modulate to maintain the SAT setpoint – 2 Degrees (Adj.).

J. Sequence of Operation – Mixed Mechanical & Economizer Control:

1. When both economizer and chilled water plant cooling are available the unit shall operate in the Mixed Mechanical & Economizer Control mode. While in this mode the first stage of cooling shall be the mixed air dampers. If the mixed air damper control is greater than 95% for a period of 5-minutes (Adj.) then the second stage of cooling shall be implemented. The second stage of cooling is the chilled water coil.

K. Sequence of Operation – Alarms:

1. General: All alarm events shall incorporate adjustable time delays.

2. Fan Alarms: Whenever the unit status and command do not match an alarm shall be generated.
   a. If the unit is commanded off and the fan status is true a fan not in auto alarm shall be generated. The unit shall continue controlling in automatic while status is true.
   b. If at any point the fan command is enabled and fan status is false the unit shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

3. Supply Air Duct Static Pressure (SADP) Alarms: The SADP shall continuously be monitored and alarmed.
   a. If the differential pressure rises to a value greater than 3 inwc (Adj.) then a high duct static pressure alarm shall be generated. When this alarm event occurs the unit shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.
   b. If the differential pressure value is less than the differential pressure setpoint - .25 inwc (Adj.) then a low differential pressure alarm shall be generated.
   c. If the differential pressure value drops to its lowest range or highest range value while the system is in operation then a sensor failure alarm shall be generated. When this alarm occurs the supply fans shall control to the minimum speed.

4. Mixed Air Low Limit Alarm: Whenever the unit mounted averaging temperature sensor for mixed air reads a value less than or equal to 45 Degrees (Adj.) the economizer dampers shall control to 100% return and 0% outside air. Once the mixed air temperature reads 50 degrees (Adj.) or greater then automatic control shall resume.

5. Freeze Stat Alarm: Whenever the unit mounted freeze stat is triggered the fan shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

6. Smoke Detector Alarm: Whenever the unit mounted smoke detector is triggered the fan shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

7. Supply Air Temperature (SAT) Alarms: The SAT shall continuously be monitored and alarmed.
   a. If the supply air temperature rises to a value greater than the current SAT setpoint + 10 Degrees (Adj.) then a high supply air temperature alarm shall be generated.
   b. If the supply air temperature drops to a value less than the current SAT setpoint - 10 Degrees (Adj.) then a low supply air temperature alarm shall be generated.
c. If the supply air temperature value drops to its lowest range or highest range value then a sensor failure alarm shall be generated. When this alarm occurs the unit controls shall automatically default to control using the re-heat supply air temperature sensor.

2.3 AIR HANDLING UNIT (CONSTANT VOLUME, HEATING ONLY)

A. Provide air-handling unit Sequence of Operation in accordance with the following written sequences.

B. Unit Description

1. The Air Handling Units are configured with ECM supply fans, heating coil and economizer capabilities. The units feed conditioned air to diffusers located throughout the air distribution ductwork.

C. AHU Modes of Operation

1. System Scheduling - The Air Handling Unit control algorithms shall employ advanced schedule/calendar architecture to facilitate scheduled occupied/unoccupied modes of operation. The schedule/calendar shall provide the ability to setup up diverse schedules of operation based on special events, holidays, and normal operation.

2. Unoccupied Mode: While operating in the unoccupied mode the unit will stage on/off based upon the zone rising above the unoccupied cooling setpoint. The unit will remain enabled until the zone is below the unoccupied cooling setpoint with a 2-degree dead-band. Unoccupied space temperature setpoints are:
   a. Unoccupied Space Heating Setpoint = 65 Degrees (Adj.)

D. Sequence of Operation – Unit Initialization:

1. Upon a unit initiation command if all safeties are in the “Normal Position” the supply fan shall be enabled and shall modulate to its minimum speed. Once enabled if the unit is not in the economizer mode the mixed air damper shall command to an adjustable minimum position.

2. Unit safeties include a unit mounted freeze stat and a return air duct mounted smoke detector. Unit safeties shall be hardwired interlocked with the supply fan starter. In addition, safeties shall be monitored and alarmed by the BAS. If either of the safeties goes off the unit shall fully disable, and the mixed air dampers and control valves shall go to their normal positions.

3. If at any point the supply fan command is enabled, and supply fan status is false the unit shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

E. Sequence of Operation – Economizer Control:

1. While operating in the economizer mode the mixed air dampers shall modulate to maintain the SAT setpoint – 2 Degrees (Adj.).

F. Sequence of Operation – Alarms:

1. General: All alarm events shall incorporate adjustable time delays.

2. Fan Alarms: Whenever the unit status and command do not match an alarm shall be generated.
a. If the unit is commanded off and the fan status is true a fan not in auto alarm shall be generated. The unit shall continue controlling in automatic while status is true.
b. If at any point the fan command is enabled and fan status is false the unit shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

3. Mixed Air Low Limit Alarm: Whenever the unit mounted averaging temperature sensor for mixed air reads a value less than or equal to 45 Degrees (Adj.) the economizer dampers shall control to 100% return and 0% outside air. Once the mixed air temperature reads 50 degrees (Adj.) or greater then automatic control shall resume.

4. Freeze Stat Alarm: Whenever the unit mounted freeze stat is triggered the fan shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

5. Smoke Detector Alarm: Whenever the unit mounted smoke detector is triggered the fan shall go into shutdown alarm. The unit shall require a software reset after the alarm event has been cleared in order to operate.

6. Supply Air Temperature (SAT) Alarms: The SAT shall continuously be monitored and alarmed.
   a. If the supply air temperature rises to a value greater than the current SAT setpoint + 10 Degrees (Adj.) then a high supply air temperature alarm shall be generated.
   b. If the supply air temperature drops to a value less than the current SAT setpoint - 10 Degrees (Adj.) then a low supply air temperature alarm shall be generated.
   c. If the supply air temperature value drops to its lowest range or highest range value then a sensor failure alarm shall be generated. When this alarm occurs the unit controls shall automatically default to control using the re-heat supply air temperature sensor.

2.4 FAN TERMINAL UNIT (FAN POWERED BOX)

A. General: Fan terminal units include cold deck damper, supply fan in parallel to the cold deck damper and hot water heating coil.

B. Sequence:
   1. On a call for heating as sensed by the room temperature sensor the cold deck modulating damper shall fully close and supply fan shall energize. The 2-way modulating control valve serving the heating coil will modulate under the control of the room sensor to maintain the room temperature setpoint.
   2. On a call for cooling the fan shall be deactivated and the heating hot water control valve shall be closed. The cold deck damper shall then modulate to maintain the room temperature setpoint.
   3. Provide configurable room temperature setpoint for heating and cooling as well as occupied and unoccupied.
   4. During morning warm-up, initiated at the associated Air Handling Unit automatic controls at the FTU are overridden and the terminal unit shall control to maintain max cooling cfm. When the Air Handling Unit leaves the morning warm-up mode the terminal unit shall resume automatic occupied control.
   5. While operating in the unoccupied mode the unit shall control to maintain.

2.5 CONSTANT VOLUME VAV BOX

A. General:
1. Constant Volume VAV units include control damper and hot water heating coil.

B. Sequence:

1. The control damper shall modulate to maintain the constant airflow cfm setpoint.
2. On a call for heating the hot water heating coil control valve shall modulate open to maintain the space temperature at setpoint.

2.6 KITCHEN EXHAUST FANS

A. General:

1. The exhaust fans are constant volume applications.

B. Sequence:

1. The fans shall be controlled via hood mounted switch
2. Make-up unit to interlock with hood fan
3. The fan shall be monitored from aux contacts or CT’s for status.

C. Alarms & Safeties:

1. Fan Failure: When the fan command is true and the fan status is false a fan failure alarm shall be generated.
2. Fan in Hand: When the fan command is false and the fan status is true a fan in hand alarm shall be generated.

2.7 MAKE-UP AIR UNIT (GAS FIRED):

A. General:

1. The fan shall energize and run with the kitchen exhaust fan. When the exhaust fan is on the Make-up Unit shall run.
2. Discharge air temperature setpoint shall be reset based upon outdoor air temperature according to the following reset schedule. All parameters shall be independently adjustable.
   a. The gas-fired heat exchanger shall have a modulating gas valve that shall modulate to maintain the discharge air temperature setpoint, 65 degrees F (adjustable).

B. Alarms & Safeties:

1. Fan Failure: When the fan command is true, and the fan status is false a fan failure alarm shall be generated.

2.8 EMERGENCY AIR DISTRIBUTION SHUTOFF:

A. General:
1. Provide an emergency shutoff switch in the HVAC control system that can immediately shut down
the air distribution and exhaust systems throughout the building and close all dampers leading to
the outside except where interior pressure and airflow and airflow control would more efficiently
prevent the spread of airborne contaminants and/or ensure the safety of egress pathways. Systems without duct connections to the outside (intake, exhaust or pressure relief) are exempt
from that requirement. The switch must be capable of shutting down all required systems and
closing all required dampers, even if the local hand/off/auto switch is in the hand position, within
30 seconds of switch activation. Locate the shutoff switch (or switches) to be easily accessible by
building occupants by locating them similarly to mass notification system (MNS) local operating
consoles (LOC) (see UFC 4-021-01 for additional information on MNS LOCS) so that the travel
distance to the nearest shutoff switch will not be in excess of 200 feet (61 meters). Ensure that the
shutoff switches are well labeled, and of a different color than fire alarm pull stations.

END OF SECTION 230993
SECTION 231123 - NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Valves.
   5. Pressure regulators.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
   1. Piping and Valves: 100 psig minimum unless otherwise indicated.
   2. Service Regulators: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.5 psig or less.

1.3 SUBMITTALS

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

B. Welding certificates.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   4. Operating-Pressure Rating: 0.5 psig maximum.
   5. End Fittings: Zinc-coated steel.
   7. Maximum Length: 24 inches.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

2.4 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BrassCraft Manufacturing Company; a Masco company.
   3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:
1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.

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. American Meter Company.
   b. Fisher Control Valves and Regulators.
   c. Invensys.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

2.6 DIELECTRIC UNIONS

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

2.7 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.8 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.9 LABELING AND IDENTIFYING

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

PART 3 - EXECUTION

3.1 OUTDOOR PIPING INSTALLATION


B. Steel Piping with Protective Coating:
1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

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

D. Exterior-Wall Pipe Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

E. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
NATURAL GAS PIPING

3.2 INDOOR PIPING INSTALLATION


B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

L. Verify final equipment locations for roughing-in.

M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

N. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
O. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.3 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.4 PIPING JOINT CONSTRUCTION

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

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

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.5 HANGER AND SUPPORT INSTALLATION

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

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

3.6 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.
B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
C. Install piping adjacent to appliances to allow service and maintenance of appliances.
D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 48 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.7 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "HVAC Identification" for piping and valve identification. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.8 FIELD QUALITY CONTROL

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

3.9 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

3.10 INDOOR PIPING SCHEDULE

A. Aboveground piping NPS 2-1/2” and smaller shall be the following:
1. Steel pipe with wrought steel fittings and threaded joints.

B. Aboveground piping NPS 3” and larger shall be the following:
   1. Steel pipe with wrought steel fittings and welded fittings.

END OF SECTION 231123
SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Chilled Water and Heating Hot Water Piping (Above Ground)
B. Condensate Drain Piping

1.2 PIPING SPECIALTIES:

A. Unions
B. Strainers

1.3 QUALITY ASSURANCE


B. All materials to be incorporated into a permanent piping system shall be new and undamaged. The piping shall be installed as shown on the design drawings and shall run either parallel or perpendicular to the building structure. All new piping shall be installed to allow for expansion and contraction without undue stress on the piping and pipe hangers.

C. Unions: All piping unions shall be of the ground joint type constructed of materials equivalent in alloy composition and strength to other fittings in the piping systems in which they are installed. Union pressure classes and end connections shall be the same as the fittings in the piping systems in which they are installed. Steel unions shall have hardened stainless steel seating surfaces on both faces. Unions shall be dielectric where connecting dissimilar metals together.

D. Unless specified otherwise, steel pipe shall be Grade A120 or Grade A53, conforming to ASTM Specifications and ANSI Specifications. All steel piping shall bear ASTM stamp on pipe. Piping not bearing ASTM stamp shall be removed and new piping shall be installed in accordance with these specifications.

E. Fittings shall be standard screwed type or screwed flange type for threaded pipe and standard steel welding type for welded pipes. Piping systems, fittings, valves, and specialty items and accessories shall be furnished, installed and rated for not less than the minimum water working pressure and hydrostatic test pressure specified for each piping system.

1.4 SUBMITTALS

A. Submit shop drawings for all piping materials in accordance with Division 1, Section 013300.
B. Shop Drawings:
1. Submit shop drawings which indicate complete material data.

C. Product Data:
   1. Provide current manufacturer’s data to show compliance with these specifications and governing regulations.

PART 2 - EQUIPMENT

2.1 JOINING MATERIALS

A. Welding materials shall comply with Section II, Part C ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded. All welding shall be done in accordance with Owner requirements as specified in Division 1.

B. Brazing materials shall comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials appropriate for the materials being joined. For copper tube and fitting joints, braze joints in accordance with ANSI B31.1.0

   1. Gaskets for flanged joints shall be full-faced for cast-iron flanges and raised faced for steel flanges. Select materials to suit the service of the piping system in which installed and which conform to their respective ANSI Standard. Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.2 CHILLED WATER AND HEATING HOT WATER PIPING (ABOVE GROUND)

A. Chilled water supply and return, hot water heating supply and return piping, condenser water piping less than 12-inches shall be Schedule 40 black steel pipe. Pipe size 1¼” and smaller shall be installed with screwed fitting and joints. Piping 1½” size through 3” size shall be installed with screwed, grooved, or welded joints and fittings. Pipe size 3½” and larger shall be installed with grooved or welding fittings and joints. Provide flanges where required for flanged connections. Leak test piping systems with 150 psi hydrostatic pressure.

   1. At Contractors option, pipe size ½” to 6” may be grooved joints with Victaulic fittings.
   2. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

      a. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

   3. Grooved Joints shall be installed in accordance with the manufacturer’s published installation instructions, on applicable piping systems.

      a. Gaskets shall be verified as suitable for the intended service. Lubricate gasket in accordance with manufacturer’s recommendations with a lubricant supplied by the coupling manufacturer that is compatible with the gasket elastomer and fluid media. Basis of Design: Victaulic Vic-Lube.
4. Grooved joint fittings shall be manufactured of ductile iron in accordance with ASTM A536; wrought steel to ASTM A234; or factory-fabricated from steel pipe conforming to ASTM A53. Fittings for use with copper-tubing systems shall comply with ASME B16.22 wrought copper or ASME B16.18 cast bronze, with copper-tubing sized grooved ends. (Flaring tube or fitting ends to accommodate alternate sized couplings is not permitted.)


   a. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
      
      i. Victaulic Style 107H, Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F.
      
      ii. Victaulic Style 07 “Zero-Flex”

   b. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77.

   c. 14-inches and Larger: AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible).

   d. Couplings for copper tubing shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity, Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F. Victaulic Style 607H.

2.3 CONDENSATE DRAIN PIPING

   A. Drain lines for condensate drain pans shall be Type ‘M’ or Type ‘L’ rigid copper tubing with sweat solder fittings and joints. Provide trap formed from pipe and fittings in all air supply unit coil drain pan drain lines. Traps shall be constructed and installed in accordance with the air handling unit manufacturer’s recommendations.

2.4 UNIONS

   A. Unions for use in ferrous pipe shall be malleable iron with brass to iron ground joint spherical seat, screwed ends, and rated for not less than 300 psi water working pressure.

   B. Unions for use with copper piping shall be cast brass or cast bronze with ground joint spherical seat and with cast brass or bronze or wrought copper sweat ends.

   C. Unions shall be installed wherever necessary for replacement or repair of equipment, valves, strainers, etc. Right and left hand couplings are not acceptable.

   D. Unions in refrigerant systems shall be designed for a maximum 400 psig working pressure, 330°F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing. Flanges for 7/8” to 1-5/8” unions shall be forged steel, and
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for 2-1/8" rough 3-1/8" shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory applied rust resistant coating.

E. Dielectric isolating type unions shall be installed wherever ferrous piping is connected to copper or copper alloy equipment or copper piping. Dielectric unions shall be rated for not less than 250 psi W.P.

1. Furnish and install dielectric unions at all locations where copper piping material is connected to any dissimilar metal. Piping, piping materials, component arrangement and installation procedures must provide and accommodate points at which dielectric breaks fully segregate dissimilar metals.

2. Fittings used shall be union type, of size and materials as required for service involved. Gaskets for fittings shall conform to manufacturer's recommendations for the intended service. Fittings shall meet all requirements of ASNI B16.8 and shall, as a minimum, be capable of effectively isolating stray electrical currents up to 600 volts.

F. Manufacturer

1. EPCO Sales Company

2. Victaulic Company Style 47

2.5 STRAINERS

A. Strainers, unless specified otherwise or shown on drawings otherwise, shall be basket or "Y" type of same size as pipe line and with cast iron body, direction of flow arrow cast in body, and removable screen of not less than .0625 inch thick (22 gauge) sheet brass perforated for total net free area opening equal to four times the area of pipe. Strainers shall have bodies drilled and tapped for drain and blow-down. Furnish and install drain valve with drain line extended to drain for strainers of 4" size and larger.

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Ream pipes and tubes. Clean off scale and dirt, inside and outside before assembly. Remove welding slag or other foreign material from piping. During construction, until system is fully operational, keep all openings in piping and equipment closed except when actual work is being performed on that item or system. Provide closures, plugs, caps, blind flanges or other similar items specifically designed for this purpose.

B. Run pipe lines straight and true, parallel to building lines with minimum use of offsets and couplings. Provide offsets only to provide headroom or clearance and to provide flexibility in pipe lines. Changes in direction of pipe lines made only with fittings or pipe bends. Changes in size made only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings of long radius type, unless otherwise indicated. Use full and double lengths of pipe wherever possible.

C. Cut pipe to exact measurement and install without springing or forcing except in case of expansion loops where cold springing is indicated. Take particular care to avoid creating, even temporarily, undue loads, forces or strains on valves, equipment or building elements with piping connections or piping supports.
D. Install piping to allow for expansion and contraction without stressing pipe or equipment connected.

E. Provide clearance for installation of insulation and for access to valves, air vents, drains and unions.
   1. Unions and flanges for servicing and disconnect are not required in installations using grooved joint couplings. (The couplings shall serve as disconnect points.)

F. Final connections to all equipment and fixtures shall be made in a manner that will permit the complete removal of any fixtures or any piece of equipment without cutting pipe lines.

G. Use main sized saddle type branch connections or directly connecting branch lines to mains in steel piping if main is at least one pipe size larger than branch for up to 6" mains; and if main is at least two pipe sizes larger than branch for 8" and larger mains. Do not project branch pipes inside main pipe.

H. Provide flanges or unions at all final connections to equipment, traps and valves to facilitate dismantling. Arrange piping and piping connections so that equipment being served may be serviced or totally removed without disturbing piping beyond final connections and associated shut-off valves.

I. Grooved joint shall be installed in accordance with the manufacturer’s written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor’s representative is not considered qualified to conduct the training.)

J. Threaded joints shall be full and clean cut. Joints shall be made up tight with joint compound or Teflon joint tape manufactured and approved for use with the contents to flow within the pipe and exposed threads of ferrous pipe shall be painted with acid-resisting paint after piping has been tested and proved tight. No caulking, lampwick, or other material shall be used for correction of defective joints.

K. Flanged joints shall be steel pipe flanges: ANSI B16.5. Steel flanges shall have raised-face, except when bolted to flat-face cast-iron flange. Bolting for services up to 500°F: ASTM A307, Grade B, with square head bolts and heavy hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Set flange bolts beyond finger tightness with indicating torque wrench to ensure equal tension in all bolts. Tighten bolts such that those 180° apart or directly opposite are torqued in sequence.

L. Water piping shall be pitched to drain at low points. Steel to copper connections shall be made with dielectric unions.

M. Expansion joints or expansion loops and offsets shall be installed where shown on plans and where necessary to provide for expansion of piping.
   1. For water systems, Victaulic flexible couplings may be used on header piping to accommodate thermal growth and contraction, and for the elimination of expansion
loops (as approved by the engineer). Where loops are required, use flexible-type couplings on the loops.

N. Weld pipe joints in accordance with ANSI B31. Qualify welding procedures, welders and operators in accordance with ANSI B31.1, paragraph 127.5 for shop and project site welding of piping work. Weld pipe joints in accordance with recognized industry practice. Bevel pipe ends at 37.5° angle where possible, smooth rough cuts and clean to remove slag, metal particles and dirt. Install welding rings for butt-welded joints. Use pipe clamps or tack-weld joints with 12" long welds. Use four welds for pipe sizes up to 10", or use eight welds for pipe sizes 12" through 20". Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions. Do not weld-out piping system imperfections by tack-welding procedures; re-fabricate to comply with requirements. Install forged branch-connection fittings wherever branch pipe is indicated.

O. Chilled water piping and hot water heating piping shall be downgraded to drain connections at low points and shall be upgraded to vent connections at high points. Vent connections shall be provided with manual air vent cocks and copper tube "pigtails" to facilitate catching water, except automatic vent valves shall be furnished and installed where indicated on drawings and drain lines shall be extended from automatic vent valves and ended over drains.

P. Drain piping for coil drain pans shall extend full size of pan outlet, or minimum of ¾". Use plugs on all joints with crosses. Provide trap on drain pan outlets on air systems to prevent blowing through trap. Extend drain line to open waste over floor drains.

3.2 INSPECTION

A. The inside and outside surfaces of all pipe, tubing, valves, and fittings shall be cleaned of all dirt, sand, loose mill scale, and other foreign materials immediately after removal from storage and before erection. After completion of all piping systems, all lines shall be thoroughly flushed or blown out before being placed in service. The Contractor shall notify the Owner prior to starting any post erecting cleaning operation in sufficient time to allow witnessing the operation. Prior to blowing or flushing erected piping systems, the Contractor shall disconnect all instrumentation and equipment, fully open all valves, and ensure that all strainer screens are in place.

B. Pipe and components on water systems shall be flushed with clean water until all discharge from the system is clean. A water sample from each system shall be analyzed for cleanliness after system is flushed with clean water. If the water analysis indicates that the system is not clean, the system shall be flushed with a precleaning chemical designed to remove oil, pipe dope, loose mill scale, and other extraneous materials. The Contractor shall submit to the Engineer the proposed precleaning chemicals for approval. This cleaning shall be followed by water flushing as described. Minimum velocities of 5 feet/second shall be maintained at all points. Flow shall be in same direction as when the system is in normal operation. Discharge shall be from low points of lines, ends or headers, and as otherwise required to flush the entire system. After flushing, any residual water shall be drained and/or blown out prior to testing.
3.3 TESTING

A. All hydraulic and pneumatic testing shall conform to ANSI B31.1, B31.5, B31.8 and B31.9. The Contractor shall apply the specified test pressure for a minimum time at least equal to the applicable standard's requirements.

B. Perform tests only after the pipe and contents have stabilized at ambient temperature and the source of test pressure is shut off. Piping tests shall apply to piping only, with all equipment, and instruments blocked off or disconnected. No component or piping shall be subjected to pressures which exceed their respective pressure ratings. Provide temporary restraints on expansion joints and flexible connections during pressure testing.

C. Hydrostatic and pneumatic tests shall apply to piping as shown on the following schedule. The pressure shall be gradually raised to the value specified and the source then blocked off. Leakage or loss of pressure in the test duration period shall not be acceptable unless otherwise noted.

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<td>Heating Water</td>
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<td>Condenser Water</td>
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D. Audible or visible procedure at no additional cost to the Owner.

E. Upon successful completion Contractor shall visually examine all joints during the tests. and approval of the tests, the Contractor shall relieve leaks detected during testing shall be cause to disapprove the test even though the maximum allowable pressure drop has not been exceeded. The Contractor shall repair all leaks and shall repeat the complete testing the piping of pressure, drain the system, and put the system into normal operation after further complying with all cleaning requirements as specified.

END OF SECTION 232113
SECTION 232116 – MECHANICAL HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK
A. Air and Dirt Separators for Closed Systems
B. Automatic Flow Control Valves
C. Balancing Valves
D. Flow Measuring and Transmitting Stations
E. Air Vent Valves (Hydronic Systems)
F. Pressure and Temperature Test Plugs
G. Pressure Regulating Valves
H. Expansion Tanks
I. "Y" Type Strainers
J. Thermal Storage (Buffer) Tanks

1.2 QUALITY ASSURANCE
A. Manufacturer's Qualifications:
   1. Firms regularly engaged in the manufacture of equipment specified within this section of types and capacities required, whose products have been in satisfactory use in similar service for a minimum of 5 years.

1.3 SUBMITTALS
A. Submit in accordance with Division 1.
B. Product Data:
   1. Submit manufacturer's catalog cut sheets, specifications, installation instructions, and dimensioned drawings for each type of manufactured hydronic specialty.
   2. Include a pressure drop curve or chart for each type and size of hydronic specialty.
   3. Submit a schedule showing manufacturer's model number, size, location, rated capacities, and features for each hydronic specialty.

PART 2 - PRODUCTS

2.1 AIR & DIRT SEPARATORS FOR CLOSED SYSTEMS
A. Air and Dirt Separators shall be coalescing type air eliminator and dirt separator on the heating and chilled water systems. All combination units shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at
specified GPM. Units specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second.

B. Units shall include an internal bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle must consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminant from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism.

C. Units shall include a valve side tap to flush floating dirt and liquid and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connection an equal distance for dirt separation.

D. Air eliminators shall be capable of removing 100% of the free air, 100% of the entrained air and up to 99.6% of the dissolved air in the system fluid. Dirt separator shall remove at least 80% of all particle 30 micron and larger within 100 passes.

E. Manufacturer

1. Spirotherm
2. Armstrong

2.2 AUTOMATIC FLOW CONTROL VALVES

A. Provide automatic flow control valves where shown on plans or where required for system balancing.

B. Valves used for flow control (balancing) of water in hydronic systems shall be factory set and shall automatically limit the rate of flow to within ±5% of the specified amount. An integral Viton O-rings union shall provide access for regulator change-out, inspection and cleaning.

C. Valves 2½” and larger shall have flanged connections. Valves 2” and smaller shall have NPT threaded connections.

D. Valves shall be installed with ports pointing upward and at an angle not greater 45 degrees from vertical. The balancing valve shall be located for convenient use and viewing.

E. Material:

1. All internal parts of the valve shall be either hard electroless nickel plated or stainless steel. Body shall be brass rated at 400 psi, 275°.

F. Accessories:

1. Balancing valve shall have a hidden memory feature to program valve with precision tamper-proof balancing setting. Valves shall be furnished with dual pressure/temperature test ports with leak-tight threaded caps for installation with 1 1/2” insulation. Each valve shall be furnished with a factory pre-molded two-piece insulating cover that is removable and that will seal-off vapor tight when installed on the valve.
2. Provide a differential pressure test kit. The kit shall consist of a 4 1/2” diaphragm gauge equipped with ten foot hoses and P/T adapters all housed in a vinyl case. Calibration shall be 0-35 PSID for 2-32 PSI spring range or 0-65 PSID for 5-60 PSI range.

G. Manufacturers:
1. AutoFlow: Model UR Series
2. Griswald

2.3 BALANCING VALVES

A. Provide balancing valves where shown on plans or where required for system balancing. Valves used for flow control (balancing) of water in hydronic systems shall be globe style design. Unless otherwise noted, balancing valves shall be rated for not less than 125 psi at 250°F. Valves 2½" and larger shall have flanged connections. Valves 2" and smaller shall have NPT threaded connections.

B. After the final balancing of the system is approved by the Engineer, each valve balance setpoint shall be permanently marked on the register so as to be clearly visible. Valves shall be installed with meter connections pointing upward and at an angle not greater 45 degrees from vertical. Indicator pointer shall not be above the horizontal. The balancing valve shall be located for convenient use and viewing.

C. Balancing valve shall have a hidden memory feature to program valve with precision tamper-proof balancing setting. Balancing valves shall be furnished with dual pressure/temperature test ports with leak-tight threaded caps and built-in check valves or cut-off cocks. Valves shall have ¾" NPT drain hose socket with drain cap. Each valve shall be furnished with a factory pre-molded two-piece insulating cover that is removable and that will seal-off vapor tight when installed on the valve.

D. Furnish and install, as shown on plans and in accordance to manufacturer’s installation instructions Each valve shall have two ¼ NPT brass metering ports with check valves and gasketed caps located on both sides of valve seat. Two additional 1/4 NPT connections with brass plugs are to be provided on the opposite side of the metering ports for use as drain connections. Drain connections and metering ports are to be interchangeable to allow for measurement flexibility when valves are installed in tight locations.

E. Valve shall provide multi-turn, 360° adjustment with a micrometer type indicator located on valve handwheel. Valve handwheel shall have hidden memory feature, which will provide a means for locking the valve position after the system is balanced. 90° turn adjustable valves are not acceptable.

F. Material:
1. Valves shall be of nonferrous copper alloy or cast iron construction with nonferrous copper alloy trim.

G. The valve shall be installed with flow in the direction of the arrow on the valve body and installed at least five pipe diameters downstream from any fitting, and at least ten pipe diameters downstream from any pump. Two pipe diameters downstream from the balance valve shall be free of any fittings. Install for unobstructed access to the valve handwheel and
metering ports for adjustment and measurement. Mounting of valve in piping must prevent sediment build-up in metering ports.

H. Each valve shall be furnished with a pre-formed removable PVC insulation jacket to meet ASTM D 1784/class 14253-C, MEA#7-87, ASTM-E-84 and ASTM-136 with a flame spread rating of 50 or less. There will be provided sufficient mineral fiberglass insulation to meet ASHRAE 90.1-1989 specifications in operating conditions with maximum Fluid Design Operating Temperature Range of 141-200°F and Mean Rating Temperature of 125°F.

I. Manufacturers:
   1. Nibco
   2. Armstrong
   3. Tour & Anderson
   4. Victaulic

2.4 FLOW MEASURING AND TRANSMITTING STATIONS

A. Flow meters for liquid service shall be of the insertion type turbine meter with an electromagnetic sensor generating a 2-12 Vdc square wave pulse. Insertion length shall be according to manufacturer’s recommendations.

B. Turndown shall be 10:1 with a flow rate range as indicated on the Equipment Schedule. Linearity shall be ±1% over operating range and repeatability shall be ±0.25%.

C. Material: Construction shall be of stainless steel for all wetted parts. Rotor bearing shall be made of long wearing low-friction material. Turbine meter shall be insulated according to manufacturer’s instructions.

D. Process connection shall be 150 lb. flange fitting with full port isolation ball valve. Flow element assembly shall be furnished complete with extraction assembly equipment which shall allow removal of the flow element from the process line without interruption of service.

E. Flow meter shall be furnished complete with mounted remote panel, 6-digit electromechanical indicator/totalizer with manual reset and a 4-20 mA output.

F. Furnish all necessary devices and connections for interfacing each meter assembly with the Building Automation System (BAS). Reference Division 17 transmitter and BAS specification

G. Manufacturers:
   1. EMCO
   2. Rosemount

2.5 AIR VENT VALVES (HYDRONIC SYSTEMS)

A. General:
   1. Provide air vent valves in water systems at all high points and at all locations as required to prevent the accumulation of air in the system. Vent valves shall be manual key type except where shown on drawings to be automatic. Manual and
automatic air vent valves shall be rated for water working pressure of not less than 250 psi.

B. Material:
1. Vent valves shall be all brass with copper tube pig-tail. Turn pig-tail downward for manual vent valves.

C. Accessories:
1. Extend drain line from automatic vent valves to floor drain. Install vent valve in locations to be accessible without requiring removal of equipment or cabinets.

2.6 PRESSURE AND TEMPERATURE TEST PLUGS

A. General:
1. Provide capped test plugs in piping systems in all locations where testing and balancing is required and where shown on drawings. At a minimum test plugs shall be provided in piping system wherever there is a change in temperature or pressure due to installed equipment. This includes but not limited to heat exchangers, coils chillers, boilers and pumps. Provide test plugs on both the inlet and outlet of the equipment.
2. Provide test plugs for all differential pressure transmitters for that pressure difference can be measured without the removal of piping.
3. Plugs shall be installed in accordance with the manufacturer's recommendations, including approach and depart distances from pipe fittings, valves, etc.

B. Material:
1. Plug shall have a ¼" NPT brass fitting with Nordel valve core seals rated up to 1000 psi at -40°F and 275°F and shall allow insertion of a pressure or temperature probe while the pipe or equipment is under pressure. Each plug fitting shall have a threaded brass cap.

C. Accessories:
1. Provide a ball valve upstream of each plug for servicing.

2.7 PRESSURE REGULATING VALVES

A. Material:
1. Water pressure regulating valves for make-up water connections to heating or cooling systems shall be adjustable type, of bronze construction with replaceable nickel alloy seat and integral stainless steel strainer. Install pressure gauge on discharge side of valve.

B. Manufacturers:
1. Watts: #135
2. Cash
3. McDonnell
2.8 EXPANSION TANK

A. Material:

1. Expansion tank for chilled and hot water systems shall be captive type expansion tank with steel shell, heavy duty elastomeric diaphragm (bladder), piping connections, air charge, and ASME rated construction for 100 psi working pressure.

B. Accessories:

1. Expansion tanks shall be complete with automatic fill and makeup water control valve with removable strainer, air purger fitting with inlet and outlet water connections, and automatic air vent valve complete with connector for extending vent line to drain. Tank shall be pressure charged as required by system. Extend vent piping from automatic vent valve and connect to condensate drain pipe above ceiling.

C. Manufacturers:

1. Bell & Gossett
2. Armstrong
3. Amtrol

2.9 "Y" TYPE STRAINERS

A. Material:

1. Strainer body shall be bronze or carbon steel with stainless steel screen. Screen size shall be selected for application.

B. Accessories:

1. Provide strainers 2½" and larger with off center blowdown to allow for near complete cleanout. Provide a shutoff valve on the blowdown and extend a blowdown line to the nearest floor drain. Provide a ball valve upstream of all strainers for servicing. Unless otherwise noted, strainers shall be rated for not less than 125 psi at 250°F. Strainers 2½" and larger shall have flanged connections; 2" and smaller shall have NPT threaded connections.

C. Manufacturers:

1. Armstrong

PART 3 - EXECUTION

A. Provide and install hydronic specialties as shown on drawings and specified above.

B. Specialties shall be installed in accordance with manufacturers written instructions.

C. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
D. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

E. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

F. Install in-line air separators in pump suction. Install drain valve on air separators 2” and larger, and pipe to discharge to nearest floor drain with air gap.

G. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual air vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

END OF SECTION 232116
SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:


1.4 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer’s test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
7. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4-inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.
1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."


C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   4. End Connections: Copper spring.

B. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
7. Maximum Operating Temperature: 240 deg F.

C. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 deg F.

D. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: Per Condensing Unit Schedule.
7. End Connections: Socket, flare, or threaded union.

E. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
9. Set Pressure: Per Condensing Unit Manufacturer Requirements.
10. Throttling Range: Maximum 5 psig.
12. Maximum Operating Temperature: 240 deg F.

F. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg F.
G. Moisture/Liquid Indicators:

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.

H. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
8. Rated Flow: Per Condensing Unit Schedule.
10. Maximum Operating Temperature: 240 deg F.

I. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
7. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

E. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

F. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

G. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

H. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Compressor.

I. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

J. Install receivers sized to accommodate pump-down charge.
3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

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

G. Install piping free of sags and bends.

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

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.
P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

       a. Fill system with nitrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer’s written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300
SECTION 232315 - REFRIGERATION SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

   A. Liquid indicators
   B. Sight glasses
   C. Strainers
   D. Refrigerant dryers
   E. Filter-dryers
   F. Solenoid valves
   G. Expansion valves
   H. Relief valves
   I. Charging valves
   J. Suction pressure regulator
   K. Receivers
   L. Flexible connections

1.2 RELATED DOCUMENTS

   A. Section 230050: Basic Mechanical Materials and Methods
   B. American National Standards Institute, ANSI:
      1. B31.5: Refrigeration Piping.
      2. Extend specified lower pressure limits to pressures below 15 psig.

1.3 QUALITY ASSURANCE

   A. Manufacturer’s Qualifications: Firms regularly engaged in the manufacture of equipment specified within this section of types and capacities required, whose products have been in satisfactory use in similar service for a minimum of 5 years.

1.4 SUBMITTALS

   A. Submit in accordance with Division 1, Section 01300.
   B. Product Data:
1. Submit catalog cuts, specifications, installation instructions, and dimensioned drawings for each steam specialty.

2. Submit schedule showing manufacturer’s figure number, size, location, rated capacities, and features for each steam specialty.

PART 2 - EQUIPMENT

2.1 LIQUID INDICATORS

A. Material: Liquid indicators shall be double port type with copper or brass body, and flared or solder ends.

B. Accessories: Provide removable seal caps on each port for inspection or refrigerant condition.

C. Manufacturers:

1. Hersey Products, Inc.
2. Mueller Company
3. Studebaker-Worthington, Inc.

2.2 SIGHT GLASSES

A. Material: Refrigerant moisture and liquid sight glasses shall be designed for minimum 450 psig safe working pressure, with socket type end connections

B. Manufacturers:

1. Alco Controls Corp.: AMI Services
2. Henry Valve Co.: Dri-Vue
3. Mueller Brass Co.: Sightmaster
4. Sporlan Valve Co.: See All

2.3 STRAINERS

A. Material: Strainers shall be angle type with brass shell and replaceable cartridge. Strainers shall be suitable for refrigerant and piping material used in system.

B. Manufacturers:

1. Mueller Brass Co.
2. Wylain, Inc.
3. Zurn Industries, Inc.

2.4 EXPANSION VALVES

A. Material:

1. Valve body shall be brass. Valves shall be thermostatic type, with internal or external equalizer and adjustable superheat setting. Valve shall be complete with capillary tube and remote sensing bulb.
B. Expansion valves shall be sized for full load, but shall not be excessively oversized at partial load. Valve shall be selected for maximum load at design operating pressure and minimum 43°F of superheat.

C. Evaluate refrigerant pressure drop through system to determine available pressure drop across each valve.

D. Maximum Safe Working Pressure: 300 psig.

E. Manufacturers:
   1. Alco Controls Corp.
   2. Controls Company of America
   3. Sporlan Valve Co.

2.5 RELIEF VALVES

A. Material:
   1. Relief valves shall be constructed and stamped in accordance with ASME specifications and bear symbol NB certification as to capacities. All refrigerant relief valves shall be sized in accordance with ANSI B9.1, designed for safe working pressure of 500 psi, minimum.

B. Accessories:
   1. Valves shall be provided with male pipe threaded connection on inlet, and flare tubing connection on outlet. Provide chained seal cap provided over charging opening.

C. Manufacturers:
   1. Henry Valve Co.: Type 52 or 53
   3. Mueller Brass Co.: Safetymaster

2.6 SUCTION PRESSURE REGULATOR

A. Material:
   1. Regulators shall have size and capacity to suit refrigerant and maximum coil loads specified, with minimum 200 psig safe working pressure, and oval flange type copper tube connections.

B. Accessories:
   1. Where indicated, valves shall be provided with remote temperature pilot/remote pressure pilot. Pilot lines shall be provided with strainer as recommended by valve manufacturer.

C. Manufacturers:
   1. Alco Controls Corp.: EPR Series
2. Controls Co. of America: Model 239
3. Hubbell Corp.: SF Series

2.7 RECEIVERS

A. Material: Receivers shall be constructed in accordance with ASME Boiler Construction Code, stamped certifying 450 psig working pressure minimum. Receivers shall be dehydrated, charged with an inert gas, and sealed prior to shipment. Charge shall not be released until piping is connected.

B. Accessories: Receivers shall be provided with liquid inlet and outlet valves, relief valves, purge valves, magnetic liquid level indicator and mounting brackets. Welding, including brackets and accessories, shall be completed in manufacturer's shop prior to shop testing and ASME stamp application.

C. Manufacturers:
   1. Acme Industries, Inc.
   2. Carrier Air Conditioning Co.
   3. Trane Co.

2.8 FLEXIBLE CONNECTIONS

A. Material:
   1. Flexible connections shall be close pitched corrugated bronze hose with single layer of exterior braiding. Flexible connections shall be at least 9 inches long with bronze fittings. Flexible connections shall have socket type end connections.

B. Manufacturers:
   1. American Brass Company: Vibration Eliminator
   2. Atlantic-Metal Hose Co., Inc.: Vibraducer
   3. Metraflex Company: Type LFF
   4. Universal Air Products: Vibra-Sorbers
   5. Universal Metal Hose Co.: Type UV-F

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instruction.

B. Liquid Indicators:
   1. Locate full-size liquid indicators in main liquid line leaving condenser.
   2. When a receiver is used in the system, install indicator in the liquid line leaving the receiver.

C. Strainers:
   1. Locate full-size strainer ahead of each automatic valve.
2. Where multiple expansion valves with integral strainers are used, install single main liquid line strainer.
3. On steel piping systems, provide strainer in suction line to remove scale and rust.
4. Install shut-off valve on each side of strainer to facilitate maintenance.

D. Sight Glass:
1. Install on all liquid and suction lines to heat recovery units.

E. Refrigerant Isolation Valves:
1. Install on all liquid and suction lines to heat recovery units.

F. Solenoid Valves:
1. Locate solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into suction line when system shuts down.

G. Unions:
1. Install on all liquid and suction lines to indoor units and outdoor condenser unit connections.

H. Temperature and Pressure ports
1. Install on all liquid, hot gas and suction lines to heat recovery boxes unit and outdoor condenser unit piping.

I. Strainer
1. Install prior to suction connection to indoor units only.

J. Flexible Connections:
1. Use only at or near compressors where it is not physically possible to absorb vibration within piping configuration.
2. Do not install any on this project.
SECTION 233113 – HVAC DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Ductwork

1.2 RELATED DOCUMENTS

A. National Fire Protection Association, NFPA:

2. NFPA 90B: Standard for Installation of Warm Air Heating and Air Conditioning Systems.

B. Underwriter's Laboratories, UL:

1. UL 181: Factory-Made Duct Materials and Air Duct Connections.

   a. American Conference of Governmental Industrial Hygienists: Industrial Ventilation.
   b. American Society of Heating, Refrigerating and Air Conditioning Engineers, ASHRAE:
   c. Sheet Metal and Air Conditioning Contractors National Association, Inc., SMACNA:

1.3 SUBMITTALS

A. Submit shop drawings for all materials in accordance with Division 1.

B. Product Data:

1. Submit manufacturer’s catalog cuts, specifications, installation instructions, and dimensioned drawings for each type of manufactured ductwork accessories.
2. Include pressure drop curve or chart for each type, and size of motorized control damper.
3. Submit schedule showing manufacturer’s figure number, size, location, rated capacities, and features for each fire damper, and control damper.
4. Submit fire protection rating, maximum velocity/pressure ratings and manufacturer’s installation instructions for each fire damper. Velocity/pressure ratings shall include both ducted and non-ducted data.
5. Submit manufacturers certified test data on dynamic insertion loss, self-noise power levels and aerodynamic performance for reverse and forward flow test for each duct silencer.

C. Airflow Monitoring and Control

1. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
a. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

b. Submit a schedule of airflow measuring devices indicating compliance with specified accuracy at minimum and maximum airflow rates.

c. Submit installation, operation and maintenance documentation.

D. Shop Drawings:

1. Submit ¼” scale fabrication drawings showing all necessary fittings, dampers and access doors.

2. Coordinate fabrication drawings with field conditions prior to submittal. Changes in layout and design required to accommodate actual field conditions shall be specifically noted on drawings.

PART 2 - EQUIPMENT

2.1 RECTANGULAR SHEET METAL DUCTWORK

A. Comply with ductwork type per the schedules on drawings.

B. Where ductwork is indicated to be exposed to view in occupied spaces, provide materials free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting. Sizes shown on drawings for rectangular ducts are sheet metal sizes, and where applicable an allowance has been made for duct liner insulation.

C. Ductwork shall be ASTM G90 galvanized steel: ASTM A525, lock-forming quality, 1.25 oz. zinc coating each side; (paint grip type where painted in exposed locations.). Gage, reinforcing and construction shall be in accordance with SMACNA Manual "HVAC Duct Construction Standards".

D. Longitudinal and corner seams shall be Types L1, L3 or L6 and in accordance with Figure 1-15 of SMACNA Manual "HVAC Duct Construction Standards".

E. Transverse joints and seams shall be made in accordance with Figure 1-4 of the SMACNA Manual "HVAC Duct Construction Standards" and of the following types:

1. Joints in the two sides of ducts shall be drive slip type T-1, T-2, or T-3.

2. Joints in the top and bottom of ducts shall be drive slip type as specified for sides, or shall be "S" slip types T-6, T-10, T-11, or T-14.

F. All take-offs from mains ducts shall be made using a 45° clinch collar to promote air flow in the direction of the take-off.

G. Housings and plenums shall be constructed of not less than 18 gage galvanized sheet steel with minimum ½" x ½" x 3/16" and 2" x 2" x 3/16" galvanized steel angles spaced at 4'-0" or less on centers for rigid and sturdy installation. Ducts less than 15" in depth may be reinforced with angles on top and bottom only.

H. The foregoing reinforcing for ducts and housings is the minimum and additional reinforcing shall be installed where necessary for elimination of excessive vibration and movement, and
where in the opinion of the Engineer, additional reinforcement is necessary. Housing connections to walls, floors and ceilings shall be made airtight with angles and silicone-based sealant. Angles shall be securely attached to the housing and the building construction.

I. Construct tees, bends, and elbows with radius minimum 1-1/2 times width of duct on center line. Where not possible and where rectangular elbows are used, provide single blade type turning vanes. Transitions in ductwork shall be tapered to an angle not to exceed 15 degrees unless specifically shown or approved otherwise.

J. Round branch takeoffs from rectangular ductwork shall be accomplished with round bellmouth fittings, constructed of heavy duty 24-gauge galvanized steel. Bellmouth takeoffs shall include air-tite 0.125" neoprene gasket to ensure a tight fitting with minimal leakage. Pre-drilled holes shall be provided for quick mounting. Bellmouth fitting shall be constructed utilizing automated machinery to ensure consistent sizing.

1. At contractor’s option, or as required in locations where listed duct height does not accommodate, round branch takeoffs shall be high efficiency 45° rectangular to round (HETO) fitting. HETO fittings shall be constructed of galvanized steel (ASTM A653 and A924) with G-60 galvanized coating. Fitting to be designed per SMACNA Third Edition 2005 section 4.8 Figure 4-6.

2. All branch takeoff fittings shall be provided with volume dampers, regardless if shown on plan or not. Volume dampers shall be as specified herein.

K. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A 167; Type, 304; with No. 4 exterior finish where exposed to view in occupied spaces, No. 2B finish elsewhere. At a minimum stainless steel ductwork shall be provided on all low-wall returns from the frille to the first 90-degree elbow or fitting above the ceiling line. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.

L. Shop fabricate ductwork in 12 ft maximum lengths. Construct and reinforce ductwork as indicated in SMACNA’s Standards as specified above.

M. Unless specifically detailed otherwise, use 45° laterals and 45° elbows for branch takeoff connections.

N. Fabricate duct fittings to match adjoining ducts, or equipment and to comply with duct requirements as applicable to fittings. Fabricate radius elbows with center-line radius equal to associated duct width; and include turning vanes in shorter radius elbows where necessary.

2.2 ROUND SHEET METAL DUCTWORK (CONCEALED AREAS)

A. Comply with ductwork type per the schedules on drawings.

B. All round ductwork shall be ASTM G90 galvanized inside and outside and shall be manufactured by a company who has had the manufacture of spiral duct as its principal business for at least 10 years. Round and flat oval sheet metal ducts shall be installed where indicated on the drawings.
C. Sheet metal gages and construction of round ducts shall be in accordance with the SMACNA Manual "HVAC Duct Construction Standards" for pressure class indicated on drawings. If pressure class is not indicated the ductwork shall be constructed to 2" w.g. pressure class.

D. Duct and fittings shall be installed with beaded slip joints fabricated on the fittings and couplings. Before assembly the outside of the joint slips shall be painted with duct adhesive/sealant and slipped into the mating duct. The connection shall be completed by utilizing sheet metal screws spaced at not more than 6 inches around the circumference of the duct. Use a minimum of 3 screws for all connections.

E. Branches from ductwork shall be accomplished with saddle tap fittings or lateral fittings. 90-degree takeoff fittings are not allowed.

F. Where coupling is used between two pieces of duct fittings, the fastening as stated above shall apply for each piece joined by a coupling. After fastening with screws, all excess adhesive shall be wiped clean from the outside of the ductwork.

G. Longitudinal seams shall be spiral type and transverse joints shall be beaded sleeve type RT-1 or companion flange type RT-2 as shown in figure 3-2 of the SMACNA Manual "HVAC Duct Construction Standards". Round ducts shall be supported with not less than 1" wide, 16-gauge galvanized steel straps as shown in figure 4-4 of the SMACNA Manual "HVAC Duct Construction Standards".

H. The use of wire for the support of round ducts will not be acceptable. The complete installation of duct systems shall provide a neat appearance, with duct runs hung level and without noticeable sag or misalignment.

I. Manufacturers:

1. Lindab, Inc.
2. Semco
3. Wesco
4. Eastern Sheet Metal

2.3 DOUBLE WALL ROUND SHEET METAL DUCTWORK (EXPOSED AREAS)

A. Comply with ductwork type per the schedules on drawings.

B. All round ductwork shall be ASTM G90 galvanized inside and outside and shall be manufactured by a company who has had the manufacture of spiral duct as its principal business for at least 10 years. Round and flat oval sheet metal ducts shall be installed where indicated on the drawings.

C. Outer Duct shall 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 (refer to on-drawing schedule).

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Gauge thickness for inner and outer ducts shall depend on ductwork diameter, per the following table:

<table>
<thead>
<tr>
<th>Duct Diameter (in)</th>
<th>Inner Duct Gauge</th>
<th>Outer Duct Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12”</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>12” &lt; 24”</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>24” &lt; 34”</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>34” &lt; 48”</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>&gt; 48”</td>
<td>Per SMACNA</td>
<td>Standards</td>
</tr>
</tbody>
</table>

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. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq.ft. x deg F at 75°F mean temperature.
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.

F. The use of wire for the support of round ducts will not be acceptable. The complete installation of duct systems shall provide a neat appearance, with duct runs hung level and without noticeable sag or misalignment.

G. Exposed ductwork shall be field painted, color as selected by architect. Refer to architectural plans and specifications for painting requirements.

H. Manufacturers:

1. Lindab, Inc.
2. Semco
3. McGill Airflow

2.4 LOW PROFILE ROOF MOUNTED HOODS

A. Provide low profile roof mounted hoods designed for intake, exhaust or relief airflow as indicated on plans and as scheduled. Hoods and bases shall be aluminum or galvanized steel, riveted and welded construction and shall be watertight at all seams and joints. The cap shall be constructed of not less than 18-gauge aluminum or 20-gauge galvanized steel. The base shall be not less than 14-gauge aluminum or 16-gauge galvanized steel.
B. Hoods shall be available in throat sizes 12" x 12" through 36" x 96". The height for a 36" x 96" unit shall not exceed 24" from the top of the roof curb to the top of the hood assembly. Furnish and install roof curb for each hood. Hoods and curbs shall be installed watertight and the installation shall be coordinated with the roofing installer. The hood base shall be securely anchored to the curb to withstand wind pressures. Where indicated on drawings, dampers shall be furnished and installed for the hood.

C. Surfaces shall be of type that will accept field painting without having to field treat the surfaces to accept paint. Interior of units shall have factory applied anti-condensate coating and units shall be furnished with bird screens.

D. Hood bases shall be hinged and provided with padlock hasps for padlocking. The anchoring of the hasp components shall be such that they cannot be removed when in the locked position.

E. Hoods shall be furnished with throat dimensions as shown on drawings. Large hoods shall be internally reinforced with structural angles, or standing seam construction to provide a secure and rigid unit. The static pressure drop through units shall not exceed the scheduled value.

F. Manufacturers:
   1. Loren Cook Co.: Type VR or VI
   2. Penn Ventilator Co., Inc.: Airette
   3. Greenheck Fan Corp.: Fabra Hood

PART 3 - EXECUTION

3.1 INSPECTION

A. Visit job site prior to fabrication and installation to verify all requirements, connections and conditions. Provide instructions to all parties with regard to shop drawing information and requirements.

B. Starting work indicates acceptance of other in-place work.

C. Before installation inspect building dimensions and service rough-in, including means of access for conditions affecting shop fabrication, equipment delivery and the installation of all ductwork and accessories.

D. Provide inserts and anchors into other work for the support of this work.
   1. Ensure these items are installed in the proper locations.
   2. Include fastening devices to attach work.
   3. Use the proper fasteners and anchors for the materials encountered and the operation and service of the equipment.

E. Install ductwork and all accessories in accordance with the manufacturer's instructions using workers skilled and familiar with the items and the installation specifications.

F. Shop assemble and test work prior to delivery to job site wherever possible. Sequence the installation and erection of work to ensure mechanical and electrical connections are affected in an orderly and expeditious manner.
G. Coordinate all cutting, fitting and patching with the other trades involved to ensure a complete and finished installation.

3.2 METHOD OF INSTALLATION

A. Comply with all of the manufacturer's best installation recommendations and instructions for all ductwork and accessories.

B. Furnish and install roof curbs for all roof mounted ductwork and accessories. Curbs shall be as specified in Section 230529 of these specifications and the height shall be as indicated on drawings, but shall be not less than 13¼" from base to top of nailer strip.

C. Securely anchor roof curb to roof structure. Securely anchor ductwork and accessories to roof curb. Coordinate flashing and counterflashing with roofing installer for a watertight installation.

D. Items with hinged bases shall be furnished with padlock hasps for padlocking. The anchoring of the hasp components shall be such that they cannot be removed when in the locked position.

E. Furnish and install all steel members and accessories necessary to provide a complete and finished installation.

F. Ducts shall be constructed, sealed and made airtight for pressures indicated on drawings. If pressure class is not indicated on the drawings, the ducts shall be sealed to 2" w.g. pressure class. All ducts shall be sealed in accordance with SMACNA Seal Class A. Fabricate and seal ductwork to maintain a maximum air leakage, inward or outward as follows:

1. Each 50 feet main or branch duct: 1%.
2. Total leakage any complete system: 5% of total air handled.

G. Provide openings in ductwork to accommodate thermometers and controllers. Provide pitot tube openings for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings provided in insulated or lined ductwork, install insulation material inside metal ring.

H. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities to the greatest extent possible.

I. The interior of all ducts and boots that can be seen through grilles, registers and diffusers shall be coated with flat black paint, except where duct is lined with black coated insulation.

J. Where exposed ductwork passes through non fire-rated walls the space between the duct and the opening shall be closed with a compacted fill of 3/4 lb. density fiberglass. Provide and install sheet metal collar of not less than 20-gauge paint-grip type galvanized sheet steel on all side of the ductwork. Overlap the opening and ductwork by 1½" on all sides. Seal collars around ductwork and opening with silicone elastomeric sealant.

K. Control Components: Install all control components in sheet metal equipment or ductwork as shown and/or indicated, including all automatic and manual control dampers, all flow measuring stations, all fire dampers, and all smoke dampers. Also, any temperature sensors or indicators, humidity sensors or indicators, flow sensors, switches, or indicators, freeze stats, static pressure sensors, and end position switches that are not DDC controls.
Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work. Coordinate with insulator to prevent installation of duct in such a way, that insulator cannot apply insulation.

Penetrations: Where ducts pass through interior partitions and exterior walls, seal space between construction opening and duct or duct insulation with sealant and sheet metal flanges of two gauges heavier than duct. Overlap opening on 4 sides by at least 1-1/2". Fasten to duct and substrate. Where ducts pass through fire rated floors, walls, or partitions, provide fire dampers, or fire/smoke dampers if indicated and provide firestopping between duct and substrate, as specified in Section 230500.

FLEXIBLE DUCTS

A. Flexible duct shall only be used where shown on the drawings. The inner liner shall be secured in place to the round duct with nylon or steel draw-bands and sealed for an airtight connection, and then the insulation and outer vapor barrier jacket shall be drawn up to completely cover the connection and shall be secured in place with a second nylon or steel draw-band for a vapor tight connection.

B. Flexible ducts shall be supported with 2" wide, 20-gauge steel straps, the use of wire for the support of flexible ducts is not acceptable. Where flexible duct is used as a bend or elbow, the included angle or the bend shall not exceed 90 degrees in any plane.

1. Maximum Length: For any duct run using flexible ductwork, do not exceed 5'-0" extended length.

START-UP AND TESTING

A. Leakage Tests: After each duct system is completed, this contractor shall test 10% of the system in accordance with the SMACNA HVAC Air Duct Leakage Test Manual. The tests shall verify that the duct system tested for each air handling unit has a total leakage rate of 1% or less of the system design cfm. Leakage from non-duct components (fire dampers, smoke dampers, volume control boxes, etc.) are an integral part of overall system leakage, and these components shall be included in duct leakage tests. Contractor shall be responsible for any remedial efforts directed at products in order to bring the system or section into compliance with the leakage rate specified.

B. Provide all blank off covers, fan connection points, and test holes required. Seal up of all test holes and removal of all covers after section of duct or duct system has been tested and approved as acceptable.

C. By means of a suitable fan and test manometers, the systems shall be pumped up to approximately 3.5" w.g. of static pressure and held for a period of ten (10) minutes. After this period the pressure shall be reduced to 2" w.g. of static pressure and the duct systems shall be visually and audibly inspected to determine that all joints are tight. After all leaks
are properly sealed, the duct shall be repressurized to 3.5" w.g. of static pressure and held for ten (10) minutes and then reduced again to 2" and all leaks rechecked. Contractor shall repair leaks and repeat tests until total leakage is less than 1% of total system design airflow.

D. Contractor is responsible for the costs associated with any retests required due to total system duct leakage greater than the 1% of total cfm value.

E. Contractor is responsible for submitting copies of certified calibration data for leakage test apparatus and the reports on the leakage tests. The report shall give an accurate description of the test procedure and results including any remedial action that was needed to obtain an acceptable test. Owner or Owner’s Representative may be present for tests at Owner’s discretion.

3.5 ADJUSTING AND CLEANING

A. Remove protective ductwork caps or cover as it is being installed.

B. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

D. Balancing: This contractor shall provide the initial balancing and adjusting of all air handling systems. All final testing and balancing will be by a testing and balancing contractor. This contractor shall assist during the final balancing and testing. Refer to Specification Section - "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork. Seal any leaks in ductwork that become apparent in the balancing process.

END OF SECTION 233113
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
4. Control dampers.
5. Static Fire dampers.
7. Combination fire and smoke dampers.
8. Turning vanes.
10. Duct-mounted access doors.
11. Branch Takeoffs.
12. Flexible connectors.
13. Round Flexible Insulated Duct.
14. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 283000 "Digital Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.
C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

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

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION


B. 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.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Manufacturer:

1. Ruskin Mfg Co.: BD2-A2 Series.
2. Pottorff.
3. Carnes.

C. Maximum Air Velocity: 2500 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: Hat-shaped, 0.090-inch-thick extruded aluminum, with mitered corners.

F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.050-inch-thick extruded aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles: Corrosion resistant synthetic, locked to blade and formed as single piece with bearings.

J. Bearings: Corrosion resistant, synthetic, formed as single piece with axles.

K. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Screen Mounting: Rear mounted in sleeve.
   a. Sleeve Thickness: 20-gage minimum.
   b. Sleeve Length: 6 inches minimum.

5. Screen Mounting: Rear mounted.
7. Screen Type: Insect.
8. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

A. Suitable for horizontal or vertical mounting.

B. Manufacturer:
   1. Ruskin Mfg Co.: CBD2 Series.
   2. Pottorff.
   3. Carnes.

C. Maximum Air Velocity: 2500 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.090-inch-thick extruded aluminum, with welded corners.

F. Blades:
   2. Material: Minimum 0.025-inch-thick roll formed aluminum.
   6. Counterbalance weights are zinc plated steel weights attached to blades. Field adjustable for final settings.

G. Blade Seals: Extruded vinyl, mechanically attached to blade edge.

H. Blade Axles: Corrosion resistant synthetic, locked to blade and formed as single piece with bearings.

I. Tie Bars and Brackets:
   1. Material: Aluminum.
   2. Rattle free with 90-degree stop.

J. Bearings: Corrosion resistant, synthetic, formed as single piece with axles.

K. Accessories:
   1. Flange on intake.
   2. Adjustment device to permit setting for varying differential static pressures.
3. Screen Mounting: Rear mounted.
5. Screen Type: Insect.

2.4 MANUAL VOLUME DAMPERS

A. Rectangular Volume Dampers:
   1. Manufacturers:
      a. Ruskin: MD35 Series
      b. Air Balance
      c. Nailor
      d. Greenheck

   2. Size: Damper widths from 6 inches to 48 inches as required.
   3. Standard leakage rating, with linkage outside airstream.
   4. Suitable for horizontal or vertical applications.
   5. Frames:
      a. Frame: 16-gauge galvanized steel, 5 inches deep.

   6. Blades:
      a. Single skin, 16-gauge galvanized steel with center V groove for reinforcement, opposed operation, maximum width of 8 inches. Blades shall be suitable for horizontal orientation.

   7. Axles: 1/2-inch diameter plated steel, hex shaped, mechanically attached to the blade.
   8. Bearings: Corrosion resistant, molded synthetic sleeve type turning in an extruded hole in the damper frame.
   9. Accessories:
      a. Locking hand quadrant.
      b. Standoff for extension though insulation.

B. Round Volume Dampers:
   1. Manufacturers:
      a. Ruskin: MDRS25 Series
      b. Air Balance
      c. Nailor
      d. Greenheck

   2. Size: Damper widths from 4 inch to 20-inch diameter as required.
   3. Standard leakage rating, with linkage outside airstream.
   4. Suitable for horizontal or vertical applications.
   5. Frames: 20 gage galvanized steel.
8. **Bearings**: Corrosion resistant, molded synthetic sleeve type turning in an extended hole in the damper frame.

9. **Accessories**:
   a. Locking hand quadrant.
   b. Standoff for extension though insulation.

### 2.5 CONTROL DAMPERS

#### A. Manufacturer:
1. Ruskin Mfg Co.: CD60 Series.
2. Arrow United Industries.
3. Penn Ventilator.

#### B. Ratings:
1. **Leakage**: Damper shall have a maximum leakage of 3 cfm/sq. ft. @ 1-inch w.g. and shall be AMCA licensed as Class 1A.
2. **Size**: Damper widths from 12 inches to 60 inches meeting Class 1A as scheduled or required.
3. **Differential Pressure**: Damper shall have a maximum differential pressure rating of 13-inch w.g. for a 12-inch blade.
4. **Velocity**: Damper shall have a maximum velocity rating of 6,000 fpm.
5. **Temperature**: Damper shall be rated for -72 to 275 degrees F.

#### C. Low-leakage rating, with linkage concealed in frame, and bearing AMCA’s Certified Ratings Seal for both air performance and air leakage.

#### D. Frames: 5 inches X minimum 16 gage roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gage U-channel.

#### E. Blades: Airfoil-shaped, single piece opposed action blades, suitable for horizontal or vertical orientation. Blades shall be galvanized steel, minimum 14 gage equivalent thickness, nominally 6 inches wide.

#### F. **Bearings**: Self-lubricating stainless steel sleeve, turning in extruded hole in frame.

#### G. Seals:
1. **Blade**: Extruded ‘Ruskiprene’ TPV type for ultra-low leakage from -76 to 350 degrees F. Mechanically attached to blade edge.
2. **Jamb**: Flexible metal compression type.

#### H. **Blade Axles**: Minimum 1/2 inches diameter plated steel, hex-shaped, mechanically attached to blade.
1. **Operating Temperature Range**: From minus 40 to plus 200 deg F.

#### I. **Accessories**:
1. **Electric Actuator**: 120 V or 24 V, modulating or 2-position control depending on application, refer to section 230923 "Direct Digital Controls System for HVAC”.

### 2.6 STATIC FIRE DAMPERS

A. Where shown on plans, in horizontal ducts passing through fire rated partitions and in vertical ducts passing through fire rated floors, furnish and install static type fire dampers. Dampers shall be interlocking folding blade type, with the blades located outside of the air stream. Dampers shall be furnished with a steel sleeve and retaining angles from the damper manufacturer to insure appropriate installation.

B. Dampers shall be constructed to comply with NFPA Bulletin 90A. Static fire dampers shall be constructed and tested in accordance with the current edition of Underwriter's Laboratories standard for fire dampers UL-555. Each static fire damper shall be marked with a UL classified 1-1/2 hour fire protection rating and "for use in static systems only".

C. Furnish each damper with 165°F fusible links for supply, return, and exhaust ducts or openings. The installation of dampers shall be in accordance with instructions to be provided by the manufacturer, describing the Underwriter's Laboratories approved installation procedure.

D. Damper frame shall be a minimum of 20-gauge galvanized steel channel mounted outside of the air stream with air tight construction. Blades shall be a minimum 24 gage galvanized steel construction, interlocking folding blade arrangement with blades stored outside of the air stream. Duct collars shall be a minimum 24 gage galvanized steel construction.

E. Horizontal dampers shall be furnished with constant force type, stainless steel closure springs. Damper frame types are indicated by symbols on drawings and shall be as herein specified:

   1. **Type "F1"**: Dampers shall be Ruskin type IBD2, Style "C" frame with collars for rectangular ductwork connections and suitable for vertical or horizontal installation.
   
   2. **Type "F2"**: Dampers shall be Ruskin type IBD2, Style "CR" frame with collars for round ductwork connections and suitable for vertical or horizontal mounting.
   
   3. **Type "F3"**: Dampers shall be Ruskin type IBD2, Style "CO" frame with collars for flat-oval ductwork connections and suitable for vertical or horizontal mounting.

F. Space between fire damper sleeve and the building construction shall be tightly sealed off with galvanized steel angle frame (not less than 10 ga.) on each side of opening, attached to fire damper sleeve and to building construction, and to comply with UL and NFPA requirements for fire damper installation.

G. Where dampers are installed in ductwork and are not located behind a removable air grille or register, the Contractor shall provide an airtight access door for access to the damper and fusible link and for inspection, regardless of whether access is indicated on drawings or not.

H. Each fire damper shipment shall include the manufacturer's UL installation instructions. All fire dampers shall be installed in accordance with the manufacturer's UL installation instructions.

I. **Manufacturers:**
1. Ruskin Mfg. Co.: IBD2
2. Air Balance, Inc.
3. Carnes
4. Perfco
5. Nailor Industries
6. Advanced Air

2.7 DYNAMIC FIRE DAMPERS

A. Where shown on plans, in horizontal ducts passing through fire rated partitions and in ver-
tical ducts passing through fire rated floors, furnish and install dynamic type fire dampers. Damper shall be interlocking folding blade type, with the blades located outside of the air stream. Dampers shall be furnished with a steel sleeve and retaining angles from the damper manufacturer to insure appropriate installation.

B. Dampers shall be constructed to comply with NFPA Bulletin 90A. Dynamic fire dampers shall be constructed and tested in accordance with the current edition of Underwriter's Laboratories standard for fire dampers UL-555. Each dynamic fire damper shall be marked with a UL classified 1-1/2 hour fire protection rating, the maximum velocity/pressure rating for both horizontal and vertical installation and "for use in dynamic systems". Dampers marked "for static systems only" shall not be installed in dynamic air handling systems.

C. Furnish each damper with 165°F fusible links for supply, return, and exhaust ducts or open-
ings. The installation of dampers shall be in accordance with instructions to be provided by the manufacturer, describing the Underwriter's Laboratories approved installation procedure.

D. Damper frame shall be a minimum of 20 gage galvanized steel channel mounted outside of the air stream with air tight construction. Blades shall be a minimum 24 gage galvanized steel construction, interlocking folding blade arrangement with blades stored outside of the air stream. Duct collars shall be a minimum 24 gage galvanized steel construction.

E. Horizontal and vertical dampers shall be furnished with constant force type, stainless steel closure springs. Damper frame types are indicated by symbols on drawings and shall be as herein specified:

1. **Type "F1"**: Dampers shall be Ruskin type DIBD2, Style "C" frame with collars for rectangular ductwork connections and suitable for vertical or horizontal installation.
2. **Type "F2"**: Dampers shall be Ruskin type DIBD2, Style "CR" frame with collars for round ductwork connections and suitable for vertical or horizontal mounting.
3. **Type "F3"**: Dampers shall be Ruskin type DIBD2, Style "CO" frame with collars for flat-oval ductwork connections and suitable for vertical or horizontal mounting.

F. Space between fire damper sleeve and the building construction shall be tightly sealed off with galvanized steel angle frame (not less than 10 ga.) on each side of opening, attached to fire damper sleeve and to building construction, and to comply with UL and NFPA require-
ments for fire damper installation.

G. Where dampers are installed in ductwork and are not located behind a removable air grille or register, the Contractor shall provide an airtight access door for access to the damper and fusible link and for inspection, regardless of whether access is indicated on drawings or not.
H. Each fire damper shipment shall include the manufacturer’s UL installation instructions. All fire dampers shall be installed in accordance with the manufacturer’s UL installation instructions.

I. Manufacturers:

1. Ruskin Mfg. Co.: DIBD2
2. Air Balance, Inc.
3. Carnes
4. Perfco
5. Advanced Air
6. Nailor Industries

2.8 CLASS III COMBINATION FIRE SMOKE DAMPERS

A. Where shown on plans, in horizontal ducts passing through fire smoke rated partitions and in vertical ducts passing through fire smoke rated floors, furnish and install combination fire smoke rated dampers. Each combination fire smoke damper shall be 1-1/2 hour rated under Underwriter’s Laboratories Standard UL-555, and shall be further classified by Underwriter’s Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL-555S, and shall bear a UL label attesting to the same.

B. The damper manufacturer shall have tested, and qualified with UL a complete range of damper sizes covering all dampers required by this specification. Testing and qualifying a single damper size is not acceptable. The leakage rating under UL-555S shall be no higher than leakage class III (40 cfm/sq. ft. at 1" w.g. static pressure; 80 cfm/sq. ft. at 4" w.g. static pressure).

C. As part of the UL qualification, the dampers shall have demonstrated a capacity to operate both open and closed under HVAC system operating conditions with pressures of at least 4" w.g. in the closed position, and 2000 FPM air velocity in the open position.

D. The dampers and the actuators shall be qualified under UL-555S to an elevated temperature of 250°F, 350°F, or 450°F depending upon the actuator. Electric actuators shall be factory installed. The damper/actuator assembly shall be supplied as a single entity which meets all applicable UL-555 and UL-555S qualifications for both dampers and actuators.

E. Provide factory assembled sleeve minimum 16" long. Sleeves shall be minimum 20 gage for dampers up to 84" wide, and 18 gage for dampers over 84" wide. Damper and actuator assembly shall be opened and closed at the factory a minimum of ten cycles to demonstrate proper and reliable damper operation.

F. Damper frames shall be a minimum of 16 gage galvanized steel structural hat channel with tabbed corners for reinforcement. Bearings shall be a stainless steel sleeve turning inside an extruded hole in the frame. Blades shall be minimum 16 gage galvanized steel construction with three longitudinal grooves for reinforcement. Jamb seals shall be stainless steel flexible metal compression type. Blade action shall be parallel.

G. Space between fire damper sleeve and the building construction shall be tightly sealed off with galvanized steel angle frame (not less than 10 ga.) on each side of opening, attached to fire damper sleeve and to building construction, and to comply with UL and NFPA requirements for fire damper installation.
H. Where dampers are installed in ductwork and are not located behind a removable air grille or register, the Contractor shall provide an airtight access door for access to the damper and fusible link and for inspection, regardless of whether access is indicated on drawings or not.

I. Provide factory fabricated style CR transition duct connections for round ductwork. Provide factory fabricated style CO transition duct connections for flat-oval ductwork. Each combination fire smoke damper shipment shall include the manufacturer's UL installation instructions.

J. Furnish each damper with 165°F fusible links for supply, return, and exhaust ducts or openings. The installation of dampers shall be in accordance with instructions to be provided by the manufacturer, describing the Underwriter's Laboratories approved installation procedure.

K. Manufacturers
   1. Ruskin: FSD35
   2. Air Balance
   3. Prefco
   4. American Warming
   5. Nailor Industries

2.9 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

C. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 REMOTE DAMPER OPERATORS

A. Description: Cable system designed for remote manual damper adjustment.

B. Tubing: Aluminum.

C. Cable: Stainless steel.

D. Wall-Box Mounting: Recessed.

E. Wall-Box Cover-Plate Material: Stainless steel.

2.11 DUCT-MOUNTED ACCESS DOORS


   1. Door:
2. AIR DUCT ACCESSORIES

2.12 BRANCH TAKE-OFF FITTINGS

A. Where shown on plans provide from rectangular ductwork to round branch ductwork high efficiency take-off type fitting. Fitting shall be minimum 24 gauge, have minimum 3/8” diam. Shaft thru damper, standoff as necessary to adjust damper without disruption insulation, and have locking quadrant.

B. Fitting shall be equal to Ductmate High Efficiency Takeoff – Tapered, Centered, or Straight as necessary. Fitting shall be minimum 24 gauge with full rod thru damper (not clamping), adjustable quadrant setpoint (no wing nut setting), and factory applied gasketing with EDPM material.

C. Equal fitting can be conical type, HETO type (rectangular to round) take-off, or round bell-mouth type. Spin-ins are not allowed.

2.13 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 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-thick aluminum sheets. Provide metal compatible with connected ducts.


1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.14 ROUND FLEXIBLE INSULATED DUCTS

A. Flexible ducts shall be round, insulated duct, factory fabricated of a spring steel wire helix or flat steel spiral covered by and bonded to a polymeric or vinyl-coated fiberglass fabric for leak-tight air seal. Inner liner shall be covered with 1" thick glass fiber insulation and an outside flexible, puncture-resistant and scuff resistant vapor barrier jacket.

B. Duct shall be U.L. listed, Class I, and shall conform to the requirements of NFPA 90A. Ducts shall be rated for not less than 4" W.G. static pressure and for air velocities up to 2500 fpm.

C. Flexible duct sizes and installation shall be as shown on the drawings. Flexible duct connections to rectangular ducts or plenum housings shall be made with spin-in fittings equipped as hereinbefore specified.

D. The inner lining shall be secured in place to the spin-in fitting or round duct with nylon or steel draw-bands for an airtight connection. The insulation and outer vapor barrier jacket shall be drawn up to completely cover the connection and shall be secured in place with a second nylon or steel draw-band for a vaportight connection.

E. The maximum installed length of the flexible duct shall not exceed 5 feet. Flexible ducts shall be supported with not less than 1" wide, 16 gage steel straps, the use of wire for the support of flexible ducts will not be allowed.

F. Manufacturers:
   1. Thermaflex: G-KM
   2. Wiremold
   3. Atco

2.15 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.
2.16 AIRFLOW MONITORING PRODUCTS INCLUDED IN THIS SECTION

A. Duct and plenum mounted airflow measurement devices

B. Fan inlet mounted airflow measurement devices

C. Acceptable Manufacturers
   1. Subject to compliance with requirements of this Section, provide products that comply with this specification by one of the following vendors:
      a. EBTRON, Inc. Model GTx116-P and GTx116-F (basis of design)
      b. Air Monitor

D. Airflow/Temperature Measurement:
   1. Provide airflow/temperature measurement devices (ATMD) where indicated on the plans.
      a. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.

E. Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
   1. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
   2. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
   3. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
   4. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
   5. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
   6. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
   7. Devices using less than two thermistors in each sensor assembly are not acceptable.
   8. Devices using platinum wire RTDs are not acceptable.
   9. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
   10. Pitot tubes and arrays are not acceptable.
   11. Vortex shedding devices are not acceptable.

F. All Sensor Probes
   1. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
   2. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
3. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.
4. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
5. Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.
6. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
7. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
8. Each sensor assembly shall not require matching to the transmitter in the field.
9. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

G. Duct and Plenum Probes

1. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
2. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
   a. Insertion mounted through the side or top of the duct
   b. Internally mounted inside the duct or plenum
   c. Standoff mounted inside the plenum
3. The number of sensor housings provided for each location shall be as follows:

<table>
<thead>
<tr>
<th>Duct or Plenum Area (sq.ft.)</th>
<th>Total # Sensors / Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>4</td>
</tr>
<tr>
<td>2 to &lt; 4</td>
<td>6</td>
</tr>
<tr>
<td>4 to &lt; 8</td>
<td>8</td>
</tr>
<tr>
<td>8 to &lt;16</td>
<td>12</td>
</tr>
<tr>
<td>&gt;=16</td>
<td>16</td>
</tr>
</tbody>
</table>

4. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

H. Fan Inlet Probes

1. Sensor assemblies shall be mounted on 304 stainless steel housings.
2. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
3. Mounting feet shall be constructed of 304 stainless steel.
4. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.
I. Transmitters

1. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

2. The transmitter shall be capable of field configuration and diagnostics using an onboard pushbutton interface and LCD display.

3. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).
   a. The transmitter shall use a switching power supply fused and protected from transients and power surges.
   b. The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.

4. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

5. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be installed at a location that is protected from weather and water.

6. The transmitter shall be capable of communicating with other devices using one of the following interface options:
   a. Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
   b. RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus
   c. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
   d. 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP
   e. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
   f. LonWorks Free Topology

7. The transmitter shall be capable of accepting an infra-red interface card for downloading airflow and temperature data or uploading transmitter configuration data using a handheld PDA (Palm or Microsoft Windows Mobile operating systems).
   a. Provide PDA upload/download software.
   b. Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter.
   c. Upload software shall be capable of displaying and saving all setup parameters that can be configured using the on-board pushbutton interface and LCD display.
   d. Provide a Microsoft Excel file capable of creating balance reports from PDA data files transferred to a Windows 98 or higher based PC.
   e. Provide a Microsoft Excel file to create configuration data files that can be transferred from a Windows 2000, Windows XP or higher based PC to a PDA for upload to one or more transmitters.
PART 3 - EXECUTION

3.1 INSPECTION

A. Visit job site prior to fabrication and installation to verify all requirements, connections and conditions. Provide instructions to all parties with regard to shop drawing information and requirements.

B. Starting work indicates acceptance of other in-place work.

C. Before installation inspect building dimensions and service rough-in, including means of access for conditions affecting shop fabrication, equipment delivery and the installation of all ductwork and accessories.

D. Provide inserts and anchors into other work for the support of this work.

   1. Ensure these items are installed in the proper locations.
   2. Include fastening devices to attach work.
   3. Use the proper fasteners and anchors for the materials encountered and the operation and service of the equipment.

E. Install ductwork and all accessories in accordance with the manufacturer’s instructions using workers skilled and familiar with the items and the installation specifications.

F. Shop assemble and test work prior to delivery to job site wherever possible. Sequence the installation and erection of work to ensure mechanical and electrical connections are affected in an orderly and expeditious manner.

G. Coordinate all cutting, fitting and patching with the other trades involved to ensure a complete and finished installation.

3.2 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain
applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts.

E. Furnish and install all manually operated volume dampers, and devices where indicated on drawings and as required to insure proper balancing and control of air systems. Volume controllers shall be equipped with proper type operators for adjustment with final balance position clearly marked.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install fire and combination fire/smoke dampers according to UL listing.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

   1. At outdoor-air intakes and mixed-air plenums.
   2. At drain pans and seals.
   3. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   4. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   5. Control devices requiring inspection.
   6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. Connect terminal units to supply ducts with maximum 6-inch lengths of flexible connectors. Do not use flexible connectors to change directions.

O. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
P. Connect flexible ducts to metal ducts with draw bands.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

S. The space between fire damper sleeve and the building construction shall be tightly sealed off with galvanized steel angle frame (not less than 10 ga.) on each side of opening. Securely attached angles to fire damper sleeve and to building construction to comply with UL and NFPA requirements for fire damper installation.

T. Where dampers are installed in ductwork, and are not located behind a removable air grille or register, the Contractor shall provide an airtight access door in rectangular ducts and an airtight access panel in round ducts. These are required for access to the damper, fusible link and for inspection. Provide and install the access doors and panels regardless of whether they are indicated on drawings or not.

U. Each fire damper shipment shall include the manufacturer's UL installation instructions. All fire dampers shall be installed in strict accordance with the manufacturer's UL installation instructions.

V. Control Components: Install all control components in sheet metal equipment or ductwork as shown and/or indicated, including all automatic and manual control dampers, all flow measuring stations, all fire dampers, and all smoke dampers. Also, any temperature sensors or indicators, humidity sensors or indicators, flow sensors, switches, or indicators, freeze stats, static pressure sensors, and end position switches that are not DDC controls.

W. Rectangular tees, bends and elbows shall be provided with turning vanes. In addition, provide manually operated volume dampers, as indicated and as needed, to ensure proper balancing and control of air systems.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

4. Inspect turning vanes for proper and secure installation.

5. Operate remote damper operators to verify full range of movement of operator and damper.

B. Clean, inspect and adjust dampers prior to system start-up to ensure equipment is operational and complete in all respects, including all accessories. Verify that all dampers are in the proper position before starting equipment.

END OF SECTION 233300
SECTION 233416 – CENTRIFUGAL EXHAUST FANS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Includes:
   1. Centrifugal roof mounted exhaust fans
   2. Centrifugal upblast roof mounted exhaust fans
   3. In-line centrifugal exhaust fans
   4. Mixed Flow In-Line Exhaust Fans for Kitchen Applications

1.2 RELATED DOCUMENTS

A. Flame-Smoke Ratings:
   1. Flame spread: 25 or less
   2. Smoke developed: 50 or less

B. Air Movement and Control Association, AMCA:
   1. Comply with AMCA standards for testing and rating fans.

C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., ASHRAE

D. Sheet Metal and Air Conditioning Contractors National Association, Inc., SMACNA:
   1. Comply with SMACNA duct construction standards for air handling units.

1.3 QUALITY ASSURANCE

A. The manufacturer shall provide the Owner with a one-year warranty. The manufacturer shall replace any equipment, assembly or part that fails due to defective material or workmanship during the warranty period.

B. Upon written notice from the Owner or Engineer the Contractor shall promptly repair any defects occurring within a one-year period from the date of final acceptance. All warranty work shall be performed by the Contractor without any cost to the Owner.

1.4 SUBMITTALS

A. Submit shop drawings for all materials in accordance with Division 1, Section 01300.

B. Shop Drawings:
   1. Submit assembly type shop drawings indicating unit dimensions, construction details, field connections and structural framing.

C. Product Data:
1. Submit manufacturer's installation, operation and maintenance instructions. Include fan performance curves showing CFM, static pressure, fan wheel RPM and BHP operating point clearly identified on the curve.

2. Submit recommend spare parts list and cost.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Disconnect switches where not furnished by the Electrical Contractor shall be furnished by the Mechanical Contractor. Disconnect switches shall be furnished and installed in accordance with the requirements of Division 26.

B. Each disconnect switch shall be NEMA 3R rated and shall include one 3 pole, 600 volt, quick-make, quick-break, manually operated switch. The handle on the switch shall have provisions to lock it in the 'open' or 'closed' position. Refer to schedule on drawings for electrical voltage characteristics.

2.2 MOTORS AND DRIVES

A. Motor speeds shall be as scheduled, and the horsepower shall be not less than shown. Motors shall be selected for quiet operation and for non-overloading performance characteristics. Motors shall be heavy-duty permanently lubricated sealed ball bearing type.

B. Motor voltage characteristics shall be as shown on the drawings. Motors shall be of the proper design for the starting and running torque requirements. Sheaves shall be adjusted for proper air delivery. Furnish controls as scheduled on drawings and as specified in Division 23.

C. All fans shall be V-belt driven unless noted otherwise. Drives shall be designed for not less than 150% of motor horsepower capabilities with cast-iron fan sheave and adjustable cast-iron motor sheave.

D. Drive belts shall be oil-resistant, non-static, non-sparking type with 24,000-hour life expectancy. Ball bearings shall be flanged, permanently lubricated, permanently sealed, and capable of 200,000 hours bearing life unless noted otherwise.

2.3 CENTRIFUGAL ROOF MOUNTED EXHAUST FANS

A. Furnish and install roof mounted exhaust fans where shown on drawings. Fan sizes, arrangements, capacities and conditions shall be as scheduled, and as shown on the drawings.

B. Fans shall be downblast discharge type and shall be constructed and rated according to AMCA, with bird screen guard on discharge outlet. Housing, inlet cone and fan wheel shall be aluminum construction. Fan wheels shall be statically and dynamically balanced. Steel fan shaft shall be turned, ground and polished to close tolerances in relationship to hub and bearings.

C. Motor and drives shall be enclosed in a weather-tight compartment separated from the exhaust air stream. Air for cooling the motor shall be supplied to the compartment, by way of an air passage, from an area not contaminated by exhaust fumes.
D. The complete drive assembly shall be mounted on vibration isolators. The drive assembly and fan wheel shall be removable from the support structure.

E. Manufacturers:

1. Loren Cook: 'ACE-B' Series
2. Penn Ventilator
3. Greenheck Fan
4. Pennberry
5. Twin City Fan

2.4 IN-LINE CENTRIFUGAL EXHAUST FAN

A. Furnish and install in-line centrifugal exhaust fans where shown on drawings. Fan sizes, arrangements, capacities and conditions shall be as scheduled, and as shown on the drawings.

B. Fans shall have inlet and discharge diameter not less than shown on schedule and shall be constructed and rated according to AMCA. Fans shall be furnished with heavy duty, self-aligning, grease lubricated, ball bearings with heavy duty pillar block mountings. Fan bearings shall have extended grease fittings. Drives shall be equipped with belt guard.

C. Manufacturers:

1. Loren Cook: "Centri-Vane"
2. Penn Ventilator
3. Greenheck Fan
4. Pennberry
5. Twin City Fan

2.5 MIXED FLOW IN-LINE EXHAUST FAN FOR KITCHEN APPLICATIONS

A. Refer to specification section 233813 "Kitchen Exhaust Systems".

PART 3 - EXECUTION

3.1 INSPECTION

A. Visit job site prior to equipment installation to verify acceptance of other in-place work.

B. Before installation inspect building dimensions and service rough-in, including means of access for conditions affecting delivery and installation of all equipment and accessories.

C. Provide inserts and anchors into other work for the support of this work.

1. Ensure these items are installed in the proper locations.
2. Include fastening devices to attach work.
3. Use the proper fasteners and anchors for the materials encountered and the operation and service of the equipment.

D. Install exhaust fans and all accessories in accordance with the manufacturer's instructions using workers skilled and familiar with the items and the installation specifications.
E. Shop assembly and test work prior to delivery to job site wherever possible. Sequence the installation and erection of work to ensure mechanical and electrical connections are affected in an orderly and expeditious manner.

F. Coordinate all cutting, fitting and patching with the other trades involved to ensure a complete and finished installation.

3.2 METHOD OF INSTALLATION

A. Comply with all of the fan manufacturer’s best installation recommendations and instructions for all exhaust fans and accessories.

B. Furnish and install roof curb for each roof mounted exhaust fan. Curbs shall be as specified in Section 230529 of these specifications and the height shall be as indicated on drawings, but shall be not less than 13½” from base to top of nailer strip.

C. All roof mounted fans shall be installed with gravity operated backdraft dampers installed in the roof curb. Dampers shall be as specified in Section 233113 “Mechanical Ductwork” of these specifications.

D. Securely anchor roof curb to roof structure. Securely anchor exhaust fan base to roof curb. Coordinate flashing and counterflashing with roofing installer for a watertight installation.

E. Exhaust fans with hinged bases shall be furnished with padlock hasps for padlocking. The anchoring of the hasp components shall be such that they cannot be removed when in the locked position.

F. Inlet and discharge connections for in-line centrifugal exhaust fans shall be made with flexible ductwork connections.

G. In-line centrifugal exhaust fans shall be installed with spring hanger type or rubber-in-shear hanger type vibration isolators. Furnish and install all steel members and accessories necessary to provide a complete and finished installation. Vibration isolators shall be selected as recommended by [ASHRAE 1991 Applications Handbook - Chapter 42 Sound and Vibration Control].

H. Provide flexible duct connection to fan base for laboratory process exhaust fan installations.

I. Install each wall mounted propeller exhaust fans with a 2-position motor operated discharge damper. Damper shall be full open when fan is energized and shall be full closed with fan is de-energized. Provide not less than the manufacturer’s recommended minimum distance between the exhaust fan and the damper.

J. Provide not less than 2” x 2” x 1/8” welded steel angle support brackets for all wall mounted propeller exhaust fans. Support brackets shall be securely attached to the wall structure and the exhaust fan assembly with removable fasteners.

3.3 START-UP AND TESTING

A. Refer to Section 23 0923 of these Specifications for Testing, Balancing and Start-up requirements.
B. Clean, inspect and adjust exhaust fans prior to start-up to ensure equipment is operational and complete in all respects, including all accessories.

END OF SECTION 233416
SECTION 233600 – AIR TERMINAL DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Single Duct Variable Air Volume Terminal Unit
B. Fan Powered Variable Air Volume Terminal Unit
C. Hot Water Coils for Terminal Units

1.2 RELATED DOCUMENTS

A. American Society for Testing and Materials
   1. Flame Spread: 25 or less; ASTM E84
   2. Smoke Developed: 50 or less; ASTM E84
B. National Fire Protection Association, NFPA:

1.3 SUBMITTALS

A. Submit in accordance with Division 1, Section 01300.
B. Shop drawings:
   1. Schematic control drawings giving specific data on all settings, ranges, action, adjustments and normal positions for each control device provided.
   2. Submit manufacture installation instructions for new boxes and retrofit instructions for existing boxes.

PART 2 - EQUIPMENT

2.1 SINGLE DUCT VAV TERMINAL DEVICE

A. Single duct volume control boxes shall be normally open for size and capacity as indicated on the drawings. Each box shall be furnished with controls factory set for the maximum and minimum supply CFM as indicated on the drawings. Units shall be selected and furnished so that the noise criteria (NC) does not exceed NC 30 based on 10 DB room absorption.

B. The control box shall be constructed of not less than 20 gage galvanized steel, shall have round inlet for duct connection of size as indicated on the drawings, shall have rectangular outlets for duct connections as indicated on the drawings, internally lined with engineered polymer foam insulation which complies to UL181 and NFPA 90A. Insulation shall be 1½ pound density, closed cell foam. Exposed fiberglass is not acceptable. The insulation shall be mechanically fastened to the unit casing. The casing shall be designed for hanging by sheet metal brackets.
C. Each control box shall be furnished with automatic volume control dampers having metal blades which seat against gasketed stops when closed, and which will not leak more than 2% against 3” S.P. when closed; pneumatic actuator and all required linkages and factory connections to dampers; flow logic controller.

D. The control boxes shall be pressure independent and shall maintain the supply CFM indicated for each box, regardless of the changes in the air system duct static pressure at the inlets of each box. The manufacturer shall furnish complete printed operation description and calibration instructions on each box.

E. If the inlet size or outlet size of the boxes differs from that shown on the drawings, the contractor shall furnish a tapered insulated adapter to properly fit the box inlet and outlet.

Boxes shall be furnished to provide the sequence of operation as called for in section 230993 of these specifications. All VAV terminal units shall fail to full cooling.

F. Before commencing with the installation survey, the existing conditions at the site and verify duct modification requirements if any. The facility shall remain occupied during the installation of this project. It shall be the contractor’s responsibility to coordinate his work with the occupants of the building. Install covering over existing open ductwork while working to avoid collecting dust and debris within existing ducts.

G. Each unit shall be furnished with a hot water heating coil at the terminal device outlet.

H. VAV terminal units shall be provided with controllers suitable for Direct Digital Controls System Specified, Refer to section 230923 “Direct Digital Controls System for HVAC”. Controls shall be factory installed in an enclosure with a hinged door. At a minimum factory mounted control panel shall include power disconnect switch (toggle switch), 120V control transformer and VAV terminal controller. At the contractors option the control devices may be field installed rather than factory installed. Coordinate controls requirements and controls options with Controls Vendor prior to shop drawing submittal.

I. Manufacturers:

1. E.H. Price
2. Enviro-Tec
3. Titus
4. Nailor Industries

2.2 FAN POWERED VAV TERMINAL DEVICE

A. Provide and install where shown on plans intermittent fan powered VAV boxes with integral electric heating coils. Units shall be constructed of 20-gauge galvanized steel. Interior shall be internally lined with engineered polymer foam insulation which complies to UL181 and NFPA 90A. Insulation shall be 1½ pound density, closed cell foam. Exposed fiberglass is not acceptable. The insulation shall be mechanically fastened to the unit casing. The casing shall be designed for hanging by sheet metal brackets. Access panels shall be provided for easy maintenance. Model number, size, cfm capacity for primary air (cooling) and fan-powered (heating), and heating coil capacity shall be as shown on drawings. Hot water heating coils shall be provided as specified in article.

B. All fan terminals shall include a filter rack with a slide track for filter removal without the use of tools and 1” disposable fiberglass filter.
C. Each primary air assembly shall be furnished with automatic volume control dampers having metal blades which seat against gasketed stops when closed, and which will not leak more than 2% against 3” S.P. when closed.

D. Fan motor assembly shall be forward curved centrifugal fan with a direct drive motor. Motors shall be General Electric ECM, variable-speed, DC, brushless motors specifically designed for use with single phase, 277 volt (or 120 volt), 60 hertz electrical input. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the blower. Motor shall maintain a minimum of 70% efficiency over its entire operating range. Provide optional remote fan speed output control for field adjustment of the fan airflow setpoint. Inductors shall be provided to minimize harmonic distortion and line noise. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from the fan to the terminal unit casing. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy.

E. The terminal unit manufacturer shall provide a factory installed PWM controller for either manual or DDC controlled fan CFM adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 Vdc signal from the DDC controller (provided by the controls contractor) to control the fan CFM. When the manual PWM controller is used, the factory shall preset the fan CFMs as shown on the schedule.

F. All electrical wiring shall be provided by the manufacturer so as to necessitate only a single point electrical connection during installation. All electrical components shall be internally wired to conform with the requirements of UL and NEC. Unit shall have been tested and rated by UL or ETL as a complete assembly including electric heating coil. Proof of rating shall be required prior to approval.

G. Flow measuring sensor shall be provided on the inlet side of the primary air for use as an averaging sensor. All fan terminal units shall fail to full cooling.

H. Fan terminals shall include an induction port sound baffle internally insulated with 3/4" dual-density fiberglass with four pounds per cubic foot skin density, rated for a maximum air velocity of 4500 fpm. Insulation must meet all requirements of UL 181 and NFPA 90-A. Raw edges exposed to the airstream shall be coated and sealed. Induction port baffle shall be constructed of not less than 22-gauge zinc-coated steel and shall be designed to be an integral part of the Fan Terminals unitized construction. The sound baffle shall be certified to produce a minimum 5 dB reduction in radiated noise levels.

I. If the inlet size or outlet size of the boxes differs from that shown on the drawings, the Contractor shall furnish a tapered insulated adapter to properly fit the box inlet and outlet.

J. Before commencing with the installation survey the existing conditions at the site and verify duct modification requirements if any. The facility shall remain occupied during the installation of this project. It shall be the contractors responsibility to coordinate his work with the occupants of the building. Install covering over existing open ductwork while working to avoid collecting dust and debris within existing ducts.
K. Each unit shall be furnished with a hot water heating coil at the fan inlet.

L. VAV terminal units shall be provided with direct digital controls. Controls shall be factory installed in an enclosure with a hinged door. At a minimum factory mounted control panel shall include power disconnect switch (toggle switch), 120V control transformer and VAV terminal controller. At the contractors option the control devices may be field installed rather than factory installed. Coordinate controls requirements and controls options with Facility controls vendor prior to shop drawing submittal.

M. Manufacturers:
   1. E.H. Price
   2. Enviro-Tec
   3. Titus
   4. Nailor Industries

2.3 HOT WATER HEATING COILS

A. Heating coil capacities and control requirements shall be as scheduled or specified. Maximum face velocity for all hot water heating coils shall not exceed 500 fpm unless noted otherwise.

B. Coils shall have non-ferrous fins mechanically bonded to copper tubes. Coils shall be pitched to provide for drainage and shall be designed for 125 psi and factory tested at 400 psi hydrostatic pressure and performance ARI certified.
   1. Hot water coils shall be completely self-draining and the finned core shall be installed in a pre-pitched casing.

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Examination
   1. Visit job site prior to equipment installation to verify all conditions, connections, and instruction to all parties with regard to shop drawings.
   2. Starting work indicates acceptance of other in-place work.

B. Field Drawings
   1. Before installation inspect building dimensions and service/maintenance requirements including means of access.

C. Installation
   1. Provide inserts and anchors built into other work for support of this work.
      a. Ensure that these items are installed in their proper location.
      b. Include fastening devices to attach work.
      c. Use proper anchoring devices for materials encountered and expected use.
2. Install terminal devices and accessories in accordance with manufacturer's recommendations using workers skilled and familiar with items and the installation specifications.

3. Sequence installation and erection to ensure mechanical and electrical connections are effected in an orderly and expeditious manner.

4. Fully coordinate work with all of the other crafts involved.

END OF SECTION 233600
SECTION 233713 – HVAC DIFFusers, REGISTERS, AND GRILLES

PART 1 - GENERAL

3.1 DESCRIPTION OF WORK

A. Diffusers
B. Grilles and Registers
C. Outside Louvers
D. Roof Hoods

3.2 RELATED DOCUMENTS

A. Air Diffusion Council, ADC

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, ASHRAE:
   1. Make air flow test and sound level measurements in accordance with ADC Equipment Test Codes and ASHRAE Standards.

C. National Fire Protection Association, NFPA:
   1. NFPA 90A: Air Conditioning and Ventilating Systems
   2. NFPA 90B: Standard for Installation of Warm Air Heating and Air Conditioning Systems

3.3 QUALITY ASSURANCE

A. The manufacturer shall provide the Owner with a one-year warranty. The manufacturer shall replace any equipment, assembly or part that fails due to defective material or workmanship during the warranty period.

B. Upon written notice from the Owner or Engineer the Contractor shall promptly repair any defects occurring within a one-year period from the date of final acceptance. All warranty work shall be performed by the Contractor without any cost to the Owner.

3.4 SUBMITTALS

A. Submit shop drawings for all materials in accordance with Division 1, Section 013300.

B. Shop Drawings:
   1. Submit shop drawings covering each item together with schedule of outlets and inlets.

C. Product Data:
1. Submit manufacturer’s data for air distribution equipment, including specifications, capacity and noise criteria. Furnish catalog cut sheets, product specifications and dimensioned drawings for each type of diffuser, grille, register, louver and hood.

2. Include performance tables marked to clearly indicate CFM, pressure drop, neck velocity, throw and noise criteria value for each item submitted.

3. Throw values shall be given in feet to terminal velocities of 150 FPM, 100 FPM and 50 FPM. All pressures shall be given in inches of water.

4. Catalog cut sheets shall be clearly marked in red ink to indicate the performance data for each item submitted.

5. Submit certified copies of tests showing water penetration for louvers in accordance with AMCA Standard 500 and complying with the requirements of the AMCA Certified Ratings Program.

6. Submit anodize finish color charts for louvers with shop drawings.

PART 2 - EQUIPMENT

3.1 GENERAL REQUIREMENTS

A. Rate units in accordance with ADC standards. Base air outlet application on space noise level of NC 35 maximum. Provide baffles to direct air away from walls, columns, or other obstructions within the radius of diffuser operation.

B. Provide boots of same manufacturer as grille or register fitted with equalizer deflector or diffuser plate as noted or scheduled on drawings. All units shall be furnished with sponge rubber gasket seal around edge with mounting surface secured in place. Foam plastic gaskets are not acceptable. All units shall have finish as specified.

C. Where supply registers are installed on exposed ductwork provide an inverted collar on the duct. The outside dimensions of the inverted collar shall be the same as the outside dimensions of the register so that the edges are even with one another. The depth of the collar shall be sufficient to contain the register and volume control damper within the collar. The register and damper shall not extend back into the duct. The collar shall not be in excess of the depth of the register and damper.

D. Refer to Architectural reflected ceiling drawings for the type of ceiling construction to determine the exact mounting frame required for each ceiling mounted grille, register and diffuser.

E. Provide quantity and sizes of grilles, registers and diffusers as indicated on drawings. Coordinate with other work, including ceiling layout, ductwork and ductwork accessories, to interface installation of units properly with other work and existing conditions.

F. Provide reinforcing bars on the back side of blades for grilles and registers when blades are 12” long or greater. Install grilles and registers for minimum sight through unit when viewed from floor.

3.2 REGISTERS

A. Supply Register SR-1 shall be steel, rectangular, double deflection type, with individually adjustable horizontal and vertical blades. Furnish units with heavy formed 1-1/4” steel borders and countersunk screw holes suitable for surface mounting.
1. Blades shall be spaced 3/4" on centers with friction pivots which allow individual blade adjustments without loosening or rattling. Front blade shall be parallel to the long dimension. Registers shall be furnished with gang-operated, opposed blade type, volume control dampers. Dampers shall be adjustable from the face of the register with screwdriver.

2. Secure overlapping frame of register to inverted duct collar, or to wall construction with oval head, countersunk screws. Screw heads shall be enameled to match the border. Finish for registers shall be off-white baked enamel.

3. Manufacturers:
   a. Titus: 272RL
   b. E.H. Price: 520L
   c. Carnes Co.: RTDA
   d. Nailor Industries

B. Exhaust Registers EG-2 shall be steel construction and rectangular configuration. Provide one set of fixed blades parallel to the long dimension. Registers for lay-in ceiling installation shall be furnished with Titus type 3 borders. Registers for installation in walls or hard ceilings shall be furnished with Titus type 1 border for surface mounting.

1. Blades shall be spaced 1/2" on centers with 30° deflection. Registers shall be furnished with gang-operated, opposed blade type, volume control dampers. Dampers shall be adjustable from the face of the register with screwdriver.

2. Secure overlapping frame of register to inverted duct collar, wall or ceiling construction with oval head, countersunk screws. Screw heads shall be enameled to match the border. Finish for registers shall be off-white baked enamel.

3. Manufacturers:
   a. Titus: 30RL
   b. E.H. Price
   c. Krueger

3.3 SUPPLY DIFFUSERS

A. Supply Diffuser SD-1 shall be 12" x 12" or 24" x 24" square plaque face type as shown on the drawings, with round neck ductwork connection. Diffusers for lay-in ceiling installation shall be furnished with Titus type 3 borders. Diffusers for installation in hard ceilings shall be furnished with Titus type 1 border for surface mounting.

1. Diffusers shall deliver airflow in a 360° pattern unless blank-off plates (sectorizing baffles) are indicated on the drawings. Blank-off plates shall be installed in the neck of the diffuser when shown to alter the discharge pattern for walls, columns or other obstructions.

2. Provide a Titus model D-75 opposed blade damper for final trim balancing (to within 5%). Each branch takeoff shall also be provided with manual volume damper for balancing purposes, per to Specification Section 233300. Integral damper shall be suitable for installation with flexible ductwork and shall be accessible by removal of plaque face. Finish for diffusers shall be off-white baked enamel.

3. Manufacturers:
   a. Titus: OMNI
   b. E.H. Price: SPD
c. Krueger

B. Supply Diffuser SD-2 shall be 24” x 24” square, architectural, panel faced type as shown on the drawings, with round neck ductwork connection. Diffuser shall be available in ¾- or 1-inch slot widths; one, two, three or four slots shall be available as standard. Diffuser shall be compatible with 24 x 24-inch modules for lay-in T-bar ceilings.

1. Diffusers must be field adjustable for vertical, one-, two-way opposite, two-way corner, three-way and four-way discharge patterns. Fixed vane diffusers are not acceptable. Each supply slot of the diffuser shall be provided with a two-element, aerodynamically curved, “ice-tong” shaped steel deflector capable of 180° pattern adjustment from the face of the diffuser and shall allow dampering of supply air for final balancing. All adjustments shall be accessible from the face of the diffuser.

2. The diffuser shall have an extruded aluminum face and factory fabricated 22-gauge steel backpan. The diffuser shall have the capacity to insert a ceiling tile into the center of the diffuser to match the ceiling system. Coordinate ceiling tile installation with general contractor. The backpan shall be removable and shall include side handles. Diffuser shall have ¼-inch thick fiberglass internal insulation. The diffuser inlet shall be located on the top of the backpan and shall have a minimum of 1 1/8-inch depth available for duct connection, with damper constructed of heavy gauge steel.

3. The diffuser finish shall be #26 white and the pattern controllers shall be black. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be H8 to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

4. The manufacturer shall provide published performance data for the architectural diffuser. The test data shall include static pressure drop, horizontal air throw pattern and NC. The diffusers shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

5. Manufacturers:

   a. Titus: MBI-30
   b. EH Price
   c. Krueger

C. Supply Diffuser SD-3 shall be a modulinear diffuser with 1-inch slot spacing of the sizes and mounting types shown on the plans and outlet schedule. Linear slot diffusers shall be available in standard one piece lengths up to 6 feet and 1 to 8 discharge slots. Diffuser lengths greater than 6 feet shall be furnished in multiple sections and will be joined together end-to-end with alignment pins to form a continuous slot appearance. All alignment components to be provided by the manufacturer.

1. The frame and support bars shall be constructed of heavy gauge extruded aluminum. The pattern controller shall be an aerodynamically curved “ice-tong” shaped steel deflector capable of 180° pattern adjustment from the face of the diffuser and shall allow dampering if required. Maximum pattern controller length shall be 3 feet, for diffusers longer than 3 feet pattern controllers shall be furnished in multiple sections.
2. The finish shall be #26 white on the face and #84 black on the pattern controllers. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

3. Heavy gauge extruded aluminum end borders, end caps and mitered corners shall be available to close off the ends of the diffusers. Plenums shall be manufactured by the same manufacturer of the linear slot diffusers. Optional diffuser curving to a 6-foot minimum radius with fixed deflection shall be available as required.

4. The manufacturer shall provide published performance data for the linear slot diffusers. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

5. Manufacturers:
   a. Titus ML-39
   b. EH Price
   c. Krueger

D. Supply Drum Louvers DL-1 shall be a high capacity, long throw type. Outer borders shall be 1-1/4” wide and shall be constructed of heavy gauge extruded aluminum. Corners shall be assembled with full penetration resistance welds with a reinforcing steel patch for extra strength. Provide with heavy gauge steel opposed blade damper, operable from face of grille.

1. Screw holes shall be countersunk for a neat appearance. Drum shall be constructed of heavy gauge extruded aluminum and shall rotate a minimum of 25 degrees up and down from center line of diffuser. Heavy extruded aluminum blades shall be individually adjustable.

2. Drum Louvers shall be extruded aluminum with #26 finish. Louver shall be provided with curved frame, with foam gasket seals, for spiral duct mounting.

3. Manufacturers:
   a. Titus: S-DL
   b. E.H. Price
   c. Krueger

3.4 GRILLES

A. Return Grilles RG-1 shall be 24” x 24” or 24” x 12” perforated steel construction with a flush face and one-piece stamped heavy gauge backpan. Grilles for lay-in ceiling installation shall be furnished with Titus type 3 borders. Grilles for installation in walls or hard ceilings shall be furnished with Titus type 1 border for surface mounting.

1. Perforations shall be minimum 3/16” diameter on 1/4” staggered centers and no less than 51% free area. Neck of grilles shall have 1-1/8” depth for easy duct connection.

2. Return grilles shall be steel construction with #26 finish. Finish shall be anodic acrylic paint, baked at 315°F for 30 minutes. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion
Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

3. Manufacturers:
   a. Titus: PAR
   b. E.H. Price
   c. Krueger

B. Exhaust Grilles EG-1 shall be 24” x 24” or 24” x 12” perforated steel construction with a flush face and one-piece stamped heavy gauge backpan. Grilles for lay-in ceiling installation shall be furnished with Titus type 3 borders. Grilles for installation in walls or hard ceilings shall be furnished with Titus type 1 border for surface mounting.

   1. Perforations shall be minimum 3/16” diameter on 1/4” staggered centers and no less than 51% free area. Neck of grilles shall have 1-1/8” depth for easy duct connection.
   2. Return grilles shall be steel construction with #26 finish. Finish shall be anodic acrylic paint, baked at 315° for 30 minutes. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

   3. Manufacturers:
      a. Titus: PAR
      b. E.H. Price
      c. Krueger

3.5 STATIONARY BLADE LOUVER

A. Manufacturers:
   1. Ruskin Mfg Co.: ELF6375DXD Series
   2. Potterff.
   3. Engineer Approved Equal.

B. Fabrication:
   1. Design: Extruded aluminum, stationary louvers with horizontally mounted drainable blades.
      a. Miami-Dade Notice of Acceptance Number: 12-0601.22.

   2. Application: Miami-Dade Approved Product for use in open structures or installations where the enclosed space is designed to accommodate water infiltration (wet rooms). Open structure building envelope protection for single unit sizes up to 88 inches wide by 120-inches high. Factory assembly. Unlimited width by 120-inches high field assembly. Unlimited height by 88” wide in vertical configuration.

   3. Frame:
Design and Construct TASMG Readiness Center – Army Aviation Site – Springfield, MO  
Project Number T1809-01

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a. Frame Depth: 6 inches, nominal.  
b. Wall Thickness: 0.081 inch, nominal.  

4. Blades:  
a. Style: Drainable, horizontally mounted.  
b. Wall Thickness: 0.081 inch, nominal.  

5. Minimum Assembly Size: 12 inches wide by 12 inches high.  
6. Maximum factory assembly size 88” x 120”.  
7. Maximum field assembly size.  
a. Unlimited width by 120” high.  
b. Unlimited height by 88: width in vertical configuration.

C. Performance Data:  
1. Based on testing 48 inches’ x 48 inches size unit in accordance with AMCA 500.  
2. Free Area: 57 percent, nominal.  
3. Free Area Size: 9.08 square feet.  
4. Maximum Recommended Air Flow through Free Area: 1,023 fpm.  
6. Maximum Pressure Drop at 1,023 fpm: 0.20 inches w.g.  

D. Accessories:  
1. Insulated Aluminum Blank-Off Panels: 0.040” aluminum sheet, 2-inch aluminum skin insulated core, factory installed with removable fasteners and neoprene gaskets.  
2. Bird Screen: Aluminum, 5/8 inch by 0.040 inch, expanded and flattened. Provide with removable and rewirable frame.  
3. Insect Screen: Aluminum, 18-16 mesh, mill finish, 0.011-inch wire. Provide with aluminum frame.  
4. Extended Sill: Formed Aluminum 3003 Alloy. Minimum nominal thickness 0.081 inch.

E. Finish: Class 1 Color Anodized.  
1. Comply with Aluminum Association AA-C21A44.  
2. Apply finish following chemical etching and pretreatment.  
3. Minimum thickness: 0.7 mils, 60-minute anodizing process.  
4. Class 1 Color Anodized: As directed by Architect.
PART 3 - EXECUTION

3.1 INSPECTION

A. Visit job-site prior to installation to verify all conditions, connections, and instruction to all parties with regard to shop drawings. Starting work means acceptance of other in-place work.

B. Before installation, inspect building dimensions and rough-in, including means of access, for conditions affecting delivery and installation.

C. Before work is installed, Architect/Engineer reserves right to make modifications to location of items to provide satisfactory coordination between Contractors.

D. Provide inserts and anchors built into other work for support of this work.
   1. Ensure these items are installed in their proper location.
   2. Include fastening devices to attach work.
   3. Use proper anchoring devices for materials encountered and usage expected.

3.2 METHOD OF INSTALLATION

A. Install grilles, registers, diffusers, louvers, hoods and accessories in accordance with manufacturer’s instructions using workers skilled and familiar with items and installation specifications and procedures.

B. Sequence installation and erection to ensure work is effected in orderly and expeditious manner. Do cutting, fitting and patching, coordinating work fully with other crafts involved. Locate all ceiling mounted grilles, registers and diffusers according to Architectural reflected ceiling drawings.

3.3 START-UP, TESTING AND TRAINING

A. Clean, test, balance and adjust equipment prior to start-up to ensure systems are operational and complete in all respects, including all accessories. Testing and balancing specified in Section 230593.

END OF SECTION 233713
SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Roof hoods.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft., acting inward or outward.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

C. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."
1.6  COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1  MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.

D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
   1. Use types and sizes to suit unit installation conditions.
   2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2  FABRICATION, GENERAL

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3  ROOF HOODS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.
B. Materials: Aluminum sheet, minimum 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.

C. Roof Curbs: As specified in 230529 “Hangers and Supports for HVAC”.

D. Bird Screening: Flattened, expanded aluminum, 3/4 by 0.050 inch thick.

E. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

F. Galvanized-Steel Sheet Finish:
   1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
   2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer’s standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
      a. Color and Gloss: As selected by Architect from manufacturer’s full range.

G. Capacities and Characteristics: As specified on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install gravity ventilators with clearances for service and maintenance.

C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.

E. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts". Drawings indicate general arrangement of ducts and duct accessories.
3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 233723
SECTION 233813 – KITCHEN EXHAUST SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Kitchen exhaust fans
B. Kitchen exhaust hoods – Type I
C. Kitchen Hood Supply Plenum
D. Kitchen Exhaust hoods – Type II
E. Kitchen exhaust Ductwork
F. Alternate Kitchen Exhaust Ductwork
G. Access Panels in Ductwork
H. Access Doors in Duct Enclosures
I. Kitchen fire suppression systems

1.2 RELATED DOCUMENTS

A. National Fire Protection Association, NFPA:

B. National Sanitary Foundation, NSF:
   1. NSF 1113

C. Underwriter's Laboratories, UL:
   1. All electrical fixtures, equipment, and connections shall be UL listed and labeled.

1.3 QUALITY ASSURANCE

A. All manufacturers shall provide the Owner with a one-year warranty except as follows. The fire suppression system manufacturer shall provide the Owner with a five-year warranty on all products manufactured by the fire suppression system manufacturer.

B. All manufacturers shall replace any equipment, assembly or part that fails due to defective material or workmanship during the warranty period.

C. Upon written notice from the Owner or Engineer the Contractor shall promptly repair any defects occurring within a one-year period from the date of final acceptance. Warranty work shall be performed by the Contractor without any cost to the Owner.
1.4 SUBMITTALS

A. Submit shop drawings for all materials in accordance with Division 1, Section 01300.

B. Shop Drawings:
   1. Submit assembly type shop drawings indicating unit dimensions, construction details, field connection details and structural framing.
   2. Provide detail drawings of equipment showing construction methods, type and gauge of metal, hardware and fittings; with plan, front elevation, and minimum 1 cross-section.
   3. Show complicated parts of typical items in cut-away perspective.
   4. Show service connection, characteristics, and wiring diagrams for control systems.
   5. Product Data:
      a. Manufacturer’s data on all items in exhaust system including catalog cut sheets, product specifications, installation instructions, operation instructions, maintenance instructions, and dimensioned drawings for each type of exhaust hood, make-up air handling unit, exhaust fan and fire suppression system.
      b. Include fan performance curves showing CFM, static pressure, fan wheel RPM and BHP operating point clearly identified on the curve.

PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. Disconnect switches shall be factory mounted as part of the packaged equipment for all motors. Disconnect switches shall be furnished and installed in accordance with the requirements of Division 16.

B. Each disconnect switch shall be NEMA 3R rated and shall include one 3 pole, 600 volt, quick-make, quick-break, manually operated switch. The handle on the switch shall have provisions to lock it in the 'open' or 'closed' position. Refer to schedule on drawings for electrical voltage characteristics.

2.2 MOTORS AND DRIVES

A. Fan and motor assemblies for supply units and exhaust fans shall be mounted on vibration isolators. Motors shall be open drip proof type, permanently lubricated, heavy duty, ball bearing type, motor horsepower shall be matched to the fan load. Refer to schedule on drawings for electrical voltage characteristics.

B. Motor and fan sheaves shall be fully machined and balanced, cast iron-type, keyed and securely attached to the fan and motor shafts. Motor sheaves shall be variable pitch type for speed adjustment to obtain final system balancing. Provide adjustable motor mount to allow proper belt tension adjustment. Drives shall be sized for 150% of the rated motor horsepower.

2.3 KITCHEN EXHAUST FANS

A. Description: Fan shall be a belt driven, tubular mixed-flow inline blower with UL 762 rating for restaurant exhaust applications.
B. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL/cUL 705) for US and Canada. For restaurant applications, fan shall be listed by Underwriters Laboratories (UL/cUL 762) for US and Canada. Fan shall bear the AMCA Certified Ratings Seal for Sound and Air Performance. Performance shall be licensed for both inlet and outlet sound.

C. Construction: The fan shall be of welded and bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 14-gauge steel with integral inlet and outlet collars for slip fit duct connections. Straightening vanes shall be included to assure maximum efficiency and low noise levels. Adjustable motor plate shall utilize threaded studs for positive belt tensioning. Copper extended lube lines shall be furnished for lubrication of fan bearings. Lifting lugs shall be provided for ease of installation. Adjustable mounting feet shall allow field adjustment of motor position. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA Certified Transit Tested Packaging.

D. Coating: Steel fan components shall be coated with an electrostatically applied, baked polyester powder coating. Each component shall be subject to a five stage environmentally friendly wash system, followed by a minimum 2 mil thick baked powder finish. Paint must exceed 1,000-hour salt spray under ASTM B117 test method.

E. Wheel: Wheel shall be steel, non-overloading, high efficiency mixed-flow type. Contoured single thickness blades shall incorporate 3-D curvature for maximum efficiency across the entire surface of the blade. Blades shall be continuously welded to the backplate and inlet shroud. Hubs shall be keyed and securely attached to the fan shaft. Wheel shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

F. Motor: Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure.

G. Blower Shaft: Blower shaft shall be AISI C-1045 hot rolled and accurately turned, ground and polished. Shafting shall be sized for a critical speed of at least 125% of maximum RPM.

H. Bearings: Bearings shall be designed and tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball or roller type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.

I. Belts and Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower.

J. Manufacturers:

1. Loren Cook Company: QMX series
2. Greenheck Fan Corporation.
3. Carnes Company.

2.4 KITCHEN EXHAUST HOODS – TYPE I

A. Comply with all on-drawing details, plans, and schedules.
B. Kitchen exhaust hoods shall be 16-gauge, type 304 stainless steel construction throughout with a #3 finish and shall bear the National Sanitation Seal of Approval (NSF) and Underwriter's Laboratories Label (UL). All exterior seams and joints shall be continuously welded liquid tight. Grind and polish all welds to a #3 finish. Internal hood joints, seams, and appendages, shall be welded or sealed grease tight.

C. The hoods shall be of the full caption type and have the capability to replace 90% of the exhausted air with make-up air. The make-up air shall be delivered, in a manner not to interfere with the cooking operations below the hood, through aluminum registers with manually operated, opposed blade, aluminum dampers.

D. The registers shall be double deflection type mounted vertically on the face of the hood for horizontal air discharge above the kitchen personnel.

E. Furnish type 304 stainless steel grease filter housings complete with U.L. classified stainless steel grease filters mounted at a 45° angle. Mesh filters are not acceptable. The filter housings shall terminate into a pitched, full length, grease trough which drains into a removable grease cup. Grease cup capacity shall not exceed one gallon.

F. Grease filters shall be all welded, stainless steel, baffle type design with heavy duty frame construction. The smooth baffle configuration shall be cleanable by soaking, spraying or washing in a conventional dishwasher. The grease filters shall be furnished in sufficient numbers to insure optimum performance as recommended by the grease filter manufacturer.

G. Provide factory installed vapor proof, grease proof, water proof, heat proof, U.L. Listed and NSF Classified incandescent light fixtures located approximately three to four feet on centers. Light fixtures shall be die cast aluminum body with brush finish to match stainless steel hood, porcelain socket with copper shell, silicone gasket, glass globe, plated steel wire guard. Globe shall be NSF Listed clear glass, plastic coated, thermal and shock resistant.

H. Fixture and wire guard shall be 5-1/2” diameter x 8-3/4” long. The light fixtures shall be factory wired to an electrical junction box located on top of the hood for field power connection. All wiring shall be routed in conduit and coded to indicate proper connection. The wiring shall conform to the latest edition of the National Electrical Code. Provide and install 100 watt light bulbs for each light fixture.

I. Provide a flush mounted, stainless steel, control panel on the front face of the canopy. The control panel shall be factory installed and wired, furnished complete with switches and indicating lights for the exhaust fans and light fixtures.

J. Manufacturers:

1. Captive-aire
2. Greenheck Fan Corporation
3. Halton

2.5 KITCHEN HOODS SUPPLY PLENUM

A. The ND Series with PSP-AC Accessory shall provide make-up air through a dual stream perforated stainless steel plenum. All seams shall be welded and have stainless steel on exposed surfaces. Unexposed surfaces shall be constructed of aluminized steel. Perforated diffuser plates shall be included in the design and to provide even air distribution. The air-
conditioned portion of the plenum shall be insulated to prevent condensation. The make-up air plenum shall be located nearest the hood and the air-conditioned plenum away from the hood. The make-up air stream and the air-conditioned stream shall not be permitted to mix until leaving the dual plenum.

2.6 KITCHEN HOODS – TYPE II

A. Heat/condensate hood is a single, double walled vent hood used for non-grease applications used for the removal of heat, vapor, etc. Hood shall have the size, shape and performance specified on the drawings.

B. Construction shall be type 304 stainless steel on hoods with gutters and 430 stainless steel on hoods without gutters, finish shall be #3 or #4 polish where exposed. Hood shall be wall or island type with fully welded 10-gauge corner hanging angles. Corner hanging angles have a 0.625 x 1.5 slot pre-punched at the factory; this allows hanging rods to be used for quick and safe installations. Hanging rod and connection is provided and installed by others.

C. Exhaust duct collar to be 4" high with 1" flanges. Refer to the drawings for duct sizes.

D. Light fixtures: Each hood shall be provided with a fluorescent type U.L. listed, suitable for heat removal hoods. Option: Incandescent or Surface Mount Incandescent lighting. The lighting shall be suitable for single phase power supply.

E. Access panel is located within the hood to provide access to components within the ballast.

F. Kitchen hoods shall be manufactured by Captive-aire, Greenheck, or Halton.

2.7 KITCHEN EXHAUST DUCTWORK

A. Kitchen exhaust ductwork shall be installed as indicated on the drawings. Ductwork shall be externally welded 16 gage carbon steel. Weld all seams, joints, penetrations and duct to hood collar connections. All welds shall be continuous and liquid tight.

B. Duct to hood collar connections may be made with 1" x 1" x 16 ga. carbon steel for carbon steel ductwork. Duct to hood collar connections may be made with 1" x 1" x 18-gauge stainless steel for stainless steel ductwork. Provide 1500°F rated gasket or sealant between the angle and hood.

C. Continuously weld the angle to ductwork and attach to hood with 1/4" weld studs or 1/4" bolts. Weld studs or bolts shall be located at each corner and maximum 4" on centers. Fasteners shall be carbon steel for carbon steel ductwork and stainless steel for stainless steel ductwork.

D. Bolts, screws, rivets and other mechanical fasteners shall not penetrate ductwork. Ducts shall be installed without the use of framing clips or traps that might collect grease. All interior surfaces of the ductwork shall be accessible for cleaning and inspection.

E. Carbon steel ductwork installed outside of the building shall be protected with high temperature paint on the exterior surface of the ductwork.

F. Ductwork shall be installed in a continuous enclosure extending from the ceiling above the hood up through the roof to maintain the integrity of the fire separation. Seal enclosure
around ductwork at ceiling and vent the enclosure above roof with weather protected openings.

G. The enclosure shall be two-hour fire resistance rated. Provide minimum 18" clearance from ductwork to interior surface of combustible enclosure. Provide minimum 6" clearance from ductwork to interior surface of limited-combustible and non-combustible enclosures. Under no circumstances shall the clearance between ductwork and enclosure be less than 6".

1. Where clearances cannot be maintained, ductwork shall be wrapped with minimum 2-hour fire barrier duct wrap typical of 3M series 615+. Installation shall be in strict accordance with manufacture’s written instructions, as shown on the approved shop drawings. Fire Barrier Duct Wrap shall be a high-temperature fibrous thermal insulation blanket encapsulated in a fiberglass-reinforced aluminized polyester foil. Duct Wrap density shall be nominal 6 pcf (and have a nominal 1-1/2" thickness. The fiber blanket shall have a continuous use limit of 1000°C. The blanket thermal resistance (R-value) at ambient temperature shall be minimum 6.3 °F-ft2-hr/Btu. Smoke Developed Index and Flame Spread Index of the bare blanket, and of the foil encapsulated blanket shall be 0/0. The foil encapsulation shall be bonded to the core blanket material.

H. Ductwork shall go directly outside and shall not pass through any fire rated walls or partitions. Kitchen exhaust ductwork shall not be interconnected with any other ventilation or exhaust system.

I. Ductwork shall be installed with minimum 18" clearance from exterior surface of the ductwork to any combustible material. Provide minimum 3" clearance for limited combustible material, and zero clearance for non-combustible material. Refer to NFPA 96 - Appendix A for material classifications.

J. All supports, hangers, bolts, weld studs, latches, wing nuts or fasteners shall be carbon steel for carbon steel ductwork and stainless steel for installation with stainless steel ductwork.

K. Welded ductwork shall be installed minimum 18" above the roof. Listed grease ductwork systems shall be installed in accordance with the terms of the listing and the manufacturer's instructions.

2.8 KITCHEN EXHAUST DUCTWORK - ALTERNATE

A. At Contractor’s option, in lieu of welded steel ductwork specified herein, contractor may provide and install double wall, factory built grease duct for use with Type I kitchen hoods, which conforms to the requirements of NFPA-96. Products shall be ETL listed to UL-1978 and UL-2221 for venting air and grease vapors from commercial cooking operation. Ductwork shall be installed in accordance with these instructions and National Fire Protection Association “NFPA 96”; Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations. Double wall grease ducts are listed for a continuous internal temperature of 500 degrees F and intermittent temperatures of 2000 degrees F.

B. The duct sections shall be constructed of an inner duct wall and an outer wall with insulation in between. The inner duct wall shall be constructed of 0.036-inch-thick, 430 type stainless steel and be available in diameters 8" through 24". The outer wall shall be constructed of stainless steel at a minimum of 0.024-inch thickness. The duct, based on model number, shall include layers of Super Wool 607 Plus insulation between the inner and outer wall. Grease duct joints shall be held together by means of formed V clamps and sealed with 3M
Fire Barrier 2000+. The duct wall assembly shall be tested and listed at zero-inch clearance, according to UL 2221 (Test for Fire Resistive Duct Enclosure Assemblies). Ductwork installed shall be in accordance with the requirements for duct enclosure Condition A and B.

C. Alternate kitchen ductwork shall be typical of Captive-Aire model DW-3Z.

2.9 ACCESS PANELS IN DUCTWORK

A. Provide openings for installation, servicing and inspection of fire protection system devices and ductwork cleaning. Clearly label all access panels with signs that read ‘ACCESS PANEL - DO NOT OBSTRUCT’. Openings in duct enclosure shall be large enough for removal of ductwork access panel.

B. Provide access panels at each change in direction of the ductwork. All openings in ductwork shall be located on top or in the sides of duct, and shall be located not less than 1-1/2” from bottom of ducts when mounted in the side of horizontal ductwork.

C. Access panels shall be the same material and thickness as the ductwork. Fasteners used to secure the access panels shall be bolts, weld studs, latches or wing nuts fabricated of carbon steel for carbon steel ductwork, and stainless steel for stainless steel ductwork.

D. Access panels shall be minimum 20" x 20" and shall have a grease tight gasket or sealant rated for 1500°F. When 20" x 20" panel will not fit in the ductwork the access panel will be as large as the ductwork will accept. Listed grease access panel assemblies shall be installed in accordance with the terms of the listing and the manufacturer’s instructions.

2.10 ACCESS DOORS IN DUCT ENCLOSURE

A. Access doors located in duct enclosure shall be an integral unit including frame, hinges, latch and closing device. Access doors shall be labeled ‘frame and fire door assembly’.

B. Frames shall be 16 gage galvanized steel with 1” mounting flange. Doors shall be 20-gauge galvanized steel front panel and liner with 1” thick, 6 lb. density thermal insulation between front panel and liner.

C. Latch shall be spring loaded with exterior key and removable interior latch handle. Access doors shall be 1-1/2 hour U.L. rated for use in partitions with fire resistance ratings of two hours or less.

D. Access doors shall be furnished with paint-grip steel finish for field painting. Access doors shall be self-closing, self-latching and operable from inside without the use of key or tools.

E. Access doors for fire rated floors and floor-ceiling assemblies shall be tested in the horizontal position in accordance with NFPA 251 and shall bear the label 'for horizontal installation'. Horizontal access doors shall be tested and listed for use as a component of a fire rated assembly.

F. Vertical access doors shall be installed in walls only and shall be mounted plumb and true. Vertical access doors shall be labeled 'for vertical installation'.
2.11 FIRE SUPPRESSION SYSTEM

A. The restaurant fire suppression system shall be a pre-engineered, liquid agent, cartridge operated type arrangement. The system shall be a fixed nozzle agent distribution network and U.L. Listed.

B. Provide a complete and operational system consisting of but not limited to the following: regulated release mechanism; regulated actuator assembly; wet chemical storage tank; enclosure for release mechanism and storage tank; nozzles; blow-off caps; detectors; cartridges; extinguishing agent; fusible links; pulley elbows; remote manual pull station; electrical gas valves; pressure switches; electrical switches; alarms and warning lights.

C. The system shall be capable of automatic detection and actuation, with local or remote manual actuation. Provide all accessories for electrical natural gas shut-off to commercial cooking appliances.

D. The system shall provide fire suppression for hoods, exhaust ductwork, exhaust plenums, grease extractors, deep fat fryers, griddles, range tops, broilers and charbroilers.

E. Provide owner's manual containing basic system operating information. Provide detailed technical manual to owner to include system description, design, installation, recharging, and maintenance procedures plus accessory installation and resetting instructions.

F. Provide a spring loaded, mechanical/pneumatic type, regulated release mechanism to deliver the expellant gas supply to one agent tanks. Include factory installed regulator deadset at 100 psi with an internal relief set at 145 psi.

G. In the 'armed' position the main spring force to the puncture pin piston shall be 150 lb. The mechanism shall have a visual indicator of the cocked or fired condition without having to open the enclosure.

H. The regulated release mechanism shall feature automatic actuation by a fusible link detection system, remote manual actuation by a mechanical pull station and local manual actuation by a push button located on the front of the release mechanism enclosure.

I. The regulated release mechanism shall contain an actuator assembly, regulator, expellant gas hose and three-gallon agent tank housed in a stainless steel enclosure with cover. The enclosure shall contain knockouts for 1/2" electrical conduit connection. The cover shall contain openings for the push button and visual indicator.

J. The regulated release mechanism shall be equipped with factory installed solenoid and switch compatible with electric gas line and appliance shut-off devices.

K. Furnish a potassium carbonate and potassium acetate based extinguishing agent designed for flame knockdown, and formulated for securement of grease related fires. The extinguishing agent shall be liquid and furnished in plastic containers with instructions for proper use and handling.

L. The liquid agent tank shall be red enamel painted carbon steel with three-gallon storage capacity. The shell assembly shall be suitable for 100 psi working pressure, 300 psi test pressure and 600 psi minimum burst pressure. The tank shall include an adapter/tube assembly. The adapter shall be 1/4" NPT female inlet with 3/8" NPT male outlet.
M. Each discharge nozzle shall be factory tested and shall also be listed with the fire suppression system for a specific application. Nozzle placement shall be determined by the size of the orifice in the nozzle tip.

N. The nozzle tip shall be brass or chrome-plated brass and shall be stamped with the part number and flow rating. The nozzle tip retainer shall be chrome-plated brass with 50 mesh screen. Each nozzle tip shall be covered by a protective metal or rubber blow-off cap.

O. The regulated release mechanism shall be compatible with a fusible link detection system. The fusible link shall be selected and installed according to the operating temperature in the exhaust system.

P. The fusible link shall be supported by a detector bracket/linkage assembly. The detector bracket shall be 16-gauge cold rolled stainless steel. The detector linkage shall be 20-gauge cold rolled stainless steel.

Q. Provide a remote manual pull station in the location indicated on the drawings. The pull station shall be the glass break-rod type and shall be connected to the release mechanism trip lever by means of a 1/16" diameter stainless steel rope installed in a 1/2" conduit.

R. The pull station shall be located not more than 125 ft. from the release mechanism. The mounting height of the pull station shall be in accordance with the authority having jurisdiction.

S. Provide U.L. Listed mechanical gas valve for automatic shut-off of natural gas to commercial cooking appliances. The gas valve shall be connected to the release mechanism by means of a pneumatic piston type air cylinder.

T. The gas valve shall have resilient seating with an aluminum body and stainless steel internal parts. The normally open valve shall be two-position action requiring 4 lb. to 15 lb. of pulling force to trip. The valve shall have an external visual indicator for the closed or open position.

U. Provide a U.L. Listed electric snap-action switch to shut-off the electrical power to the commercial cooking appliances located under the exhaust hood. The switch shall be single-pole double-throw and rated for 20 amps at 120 volts. The switch shall be interfaced with the shunt-trip beaker in the electrical panel for the commercial cooking appliances located under the exhaust hood.

V. Provide regulated actuator assembly connected to the cartridge receiver outlet of the regulated release mechanism to assist the simultaneous delivery of extinguishing agent. The assembly shall consist of a regulated actuator deadset at 100 psi with internal relief set at 145 psi; regulator; expellant gas hose; extinguishing agent tank located in a stainless steel enclosure with cover. Provide knockouts in the enclosure for installation of expellant gas line.

W. Manufacturers:

1. Ansul Fire Protection: Model R-102
PART 3 - EXECUTION

3.1 INSPECTION

A. Visit job-site prior to equipment installation to verify all ventilation outlets, utility and electrical service connections, and instruction to all parties with regard to shop drawings. Starting work means acceptance of other in-place work.

B. Before installation, inspect building dimensions and service rough-in, including means of access, for conditions affecting delivery and installation of hood.

C. Before work is installed, Architect/Engineer reserves right to make modifications to location of fans, exhausters, ducts, or other equipment to provide satisfactory coordination between Contractors.

D. Provide inserts and anchors built into other work for support of this work.
   1. Ensure these items are installed in their proper location.
   2. Include fastening devices to attach work.
   3. Use proper anchoring devices for materials encountered and usage expected.

3.2 METHOD OF INSTALLATION

A. Install hood and accessories in accordance with manufacturer’s instructions using workers skilled and familiar with items and installation specifications and procedures. Shop assemble work where possible, and test at shop.

B. Sequence installation and erection to ensure mechanical and electrical connections are effected in orderly and expeditious manner. Do cutting, fitting and patching, coordinating work fully with other crafts involved. Center all hood openings in accordance with manufacturer’s recommendation.

3.3 START-UP, TESTING AND TRAINING

A. Demonstrate kitchen exhaust, make-up air and fire suppression systems operation for Owner and Engineer/Architect. Clean, test, balance and adjust equipment prior to demonstration to ensure correct services are provided and hood is operational and complete in all respects, including all accessories. Testing and balancing specified in Section 15990.

B. Prior to systems demonstration, submit operating and maintenance manuals. Make arrangements for demonstration minimum of two weeks in advance, and coordinated with Owner and Engineer/Architect.

END OF SECTION 233813
SECTION 237313 – MODULAR INDOOR CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Insulation and Casing
B. Water Coils
C. Drain Pans
D. Fans
E. Vibration Isolators
F. Mixing Box
G. Filters

1.2 RELATED DOCUMENTS

A. Air Conditioning and Refrigeration Institute, ARI:
   1. ARI 410: Forced-Circulation Air Cooling and Air Heating Coils
   2. ARI 430: Central Station Air Handling Units
   3. Unit sound ratings will be reported in accordance with ARI 260 for inlet and discharge sound power levels.
B. Underwriter's Laboratories, UL or ETL
C. Air Movement and Control Association, AMCA: Comply with AMCA standards for testing and rating fans, and testing louvers, dampers, and shutters.
D. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., ASHRAE:
E. Sheet Metal and Air Conditioning Contractors National Association, Inc., SMACNA: Comply with SMACNA duct construction standards for air handling units.
F. Reference Section 233113 for motor operated dampers and Section 230993 for electric actuators

1.3 QUALITY ASSURANCE

A. Units shall display ARI certification symbols.
B. All electric components for air handling units shall be listed and labeled by UL or ETL.
C. Comply with UL and ETL standards for safety performance of air filter units listed Class I or Class II, as approved by local authorities.
1.4 SUBMITTALS
A. Shop drawings, project data and samples furnished by the manufacturer shall illustrate materials, equipment or workmanship, and establish standards by which the work will be judged. Submit in accordance with Section 230500 “Mechanical General Provisions.”

B. Product Data:
1. Submit manufacturer's installation and maintenance instructions.
2. Provide performance and capacity data for each coil scheduled.
3. Provide performance data for each component and accessory scheduled and/or specified including filters, dampers, motors, humidifiers etc.
4. Include fan curves showing CFM, static pressure and RPM operating point identified on the curve.

1.5 DELIVERY
A. Unpainted units will be shrink-wrapped prior to shipment. Painted units will be covered with tarps prior to shipment.
B. Openings will be protected against damage from shipping
C. Loose-shipped items will be packed, protected and secured with units.

1.6 WARRANTY
A. Manufacturer shall warranty unit and factory packaged controls for eighteen months from date of shipment. Warranty will be limited to manufacturer's defects. Warranty includes parts and labor during this period. Manufacturer shall be available 24 hours a day, 7 days a week, to respond to a service call. Warranty does not include parts associated with routine maintenance, such as belts, air filters, etc. Warranty does not extend to alterations, modifications, or external components installed after unit is shipped.

PART 2- EQUIPMENT
2.1 MANUFACTURERS
A. Subject to compliance with requirements, provide Trane units as indicated on drawings, or a comparable product by one of the following:

1. Valent
2. AAON
3. Daikin
4. Engineer Approved Equal

2.2 AIR HANDLING UNIT
A. Flame-Smoke Ratings shall comply with the following:

1. Flame spread: 25 or less.
2. Smoke developed: 50 or less
B. Package air handling units shall be furnished as a complete package including fans, dampers, coils, and other miscellaneous items as shown on drawings and as specified hereinafter.

C. Select size, NBS test efficiency, initial and final resistance of filters to agree with types specified hereinafter. Provide number of tube rows, air and water pressure drops, and features such as discharge arrangement, motor and drive location, drainability, support and venting of coils as shown and/or scheduled on drawings.

2.3 CONSTRUCTION

A. Casing leakage will not exceed 0.5 CFM/square foot of cabinet area at 5” positive or 6” negative static pressure differential across casing.

B. Panel deflection will not exceed L/240 at positive 5” or negative 6” static pressure differential across casing.

C. Unit casing will consist of an insulated structural frame with insulated roof, wall, and floor panels.

D. Removal of wall panels will not affect structural integrity of units.

E. Unit will have double wall, 2” insulated panels for walls, roof, and floor constructed of G90 mill galvanized sheet steel.

F. Floor panels will be double wall construction, designed to provide at most L/240 deflection when subjected to a 300 lb. load at mid-span.

G. Unit casing and frame will be insulated with spray injected foam to achieve thermal resistance of R13 hr-ft²-°F/BTU.

   1. Insulation application meets the requirements of NFPA 90A.
   2. Drain pans will be insulated with spray injected foam.

H. Double wall access doors will be provided on sections as shown on product drawings.

   1. Stainless steel hinges permit a 180° door swing.
   2. Access door will be of the same material type as exterior/interior casing.
   3. Access door latches will use a roller cam latching mechanism.

I. View ports will be double-pane tempered glass. Provide view ports in all access doors.

J. Primary drain pans comply with the guidelines of ASHRAE 62.

   1. Drain pans will be double sloped at least 1/8” per foot, and have no horizontal surfaces.
   2. Drain connection material will be the same as drain pan.
   3. Drain pans drain to one point.
   4. Drain connections will be welded to drain pans.
   5. Drain pans will have at least 1” clearance between pan and coil supports.
   6. Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall be a minimum of 3” above the base rail to aid in proper
condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2” thickness of insulation under drain pan.

K. Auxiliary drain pans comply with the guidelines of ASHRAE 62, and will be supplied in segments as shown in performance specifications.

1. Drain pans will be double sloped at least 1/8” per foot, and have no horizontal surfaces.
2. Drain connection material will be the same as drain pan.
3. Drain pans drain to one point.
4. Drain connections will be welded to drain pans.
5. Drain pans will have at least 1” clearance between pan and coil supports.

L. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.

M. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.

N. A formed G60 galvanized steel base rail shall be provided by the unit manufacturer for structural rigidity and condensate trapping. The base rail shall be constructed with 12-gauge nominal for unit sizes 003 - 035 and 10-gauge nominal for unit sizes 040 - 090. The following calculation shall determine the required height of the baserail to allow for adequate drainage. Use the largest pressure to determine base rail height. (Negative)/(Positive) static pressure (in)/(2) + 4” = required baserail height. Should the unit baserail not be factory supplied at this height, the contractor is required to supply a concrete housekeeping pad to make up the difference.

2.4 WATER COILS

A. Certification: Acceptable water cooling and water heating coils shall be certified in accordance with AHRI Standard 410 and bear the AHRI label. Coils exceeding the scope of the manufacturer’s certification and/or the range of AHRI’s standard rating conditions will be considered provided the manufacturer is a current member of the AHRI Forced Circulation Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with AHRI Standard 410. Manufacturer must be ISO 9002 certified.

B. Water cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5” beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing
surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

2. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

3. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.

4. Coil connections shall be carbon steel, NPT threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.

5. Coil casing shall be a formed channel frame of stainless steel.

C. Water heating coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

2. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

3. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.

4. Coil connections shall be carbon steel, threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.

5. Coils shall be furnished as an uncased galvanized steel track to allow for thermal movement and slide into a pitched track for fluid drainage.

D. Coils will have a 1/4" FPT plugged vent or drain tap on each connection that is accessible from outside the unit. Coils circuited for 3/4 serpentine or greater will allow for complete draining and venting when unit is installed on a level surface.

1. Spool shaped coil grommets will be provided to insulate and seal coil penetrations.
2. Water coils will be designed to operate at 250 psig and up to 300°F and will be factory tested with 325 psig compressed air under water.

2.5 FANS

A. Provide ECM, motorized impeller fan(s). Fan assembly shall include fan, fan base, and a motor and shall be dynamically balanced by the fan manufacturer.

1. Motor control panel shall come with a low voltage terminal strip and shall include terminals for Fan ON/OFF, 0-10V signal, and fan fault.
2. Motor control panel shall come equipped with a fused disconnect.
3. Fan section shall come equipped with a motor control panel mounted on the fan section. Both line voltage and low voltage wiring shall be done by the factory. Each fan shall have an isolation switch.
4. Motor shall be brushless DC type with a permanent magnet rotor.
5. Inverter shall be integral to the motor and come as an assembly from the fan manufacturer.

B. If individual ECM-driven motorized impeller fans are not available, direct drive plenum fans of the same quantity, CFM, static pressure, redundancy, static efficiency, as well as an acceptable fan curve, may be provided.

1. Each direct drive plenum fan in the array must be driven by an individual variable frequency drive to allow for individual fan control, status, and alarming. Fan arrays with a single VFD per array, single VFD per row, or any amount of VFDs less than that of fans, will not be accepted.
2. If substitutions of fans are made, it is the responsibility of the contractor to coordinate with all required trades to ensure a fully operational system. Substitutions also resulting in a change in unit physical dimensions shall also be the responsibility of the contractor to fully coordinate the installation of unit(s) and routing of associated components.

2.6 BEARINGS AND DRIVES

A. Bearing shall be foot mounted on structural steel framework integral with housing, base and cabinet roof and be double spherical, grease split pillow block housings, equivalent to SAF series 22500 with average life of 1,000,000 hours maximum operating conditions for class of fan furnished.

B. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

2.7 VIBRATION ISOLATION

A. Vibration isolation springs shall be free-standing, unhoused, stable steel springs, with leveling bolts, selected to a maximum transmissibility of 5 percent. The vibration isolation shall be installed in such a manner that a neoprene, or fiberglass high frequency absorber is used and no continuous metal-to-metal contact is present between the fan integral base and the base of the fan cabinet. Vibration isolation bases shall have thrust restraints to restrain fan assembly in vertical and horizontal direction.

B. Should a vibration problem exist it is the unit manufacturer’s responsibility to resolve this problem to the satisfaction of the Owner and the Engineer.
2.8 MIXING BOX

A. Furnish a mixing section where indicated on drawings with 2 sets of opposed blade, low-leakage steel dampers mounted on steel shafts supported in bronze bearings and with shaft extensions for damper motor connections. Dampers shall have stainless steel jamb seals along end of dampers. Connecting linkage and ABS plastic end caps shall be provided when return and outside air dampers are each sized for full airflow. Damper leakage rate shall be less than two tenths of one percent at 2” static pressure differential – tested in accordance with AMCA Standard 500.

2.9 FILTERS

A. Filter access will be provided via access doors on filter segments or adjacent segments as required by filter loading scheme. See product drawings for details.

B. Provide throw-away type, 2-inch-thick, stored in cabinet for use until time of acceptance; then, replace filters with renewable media filters in permanent steel frames.

   1. Media shall be 2-inch-thick glass fiber blanket, factory-sprayed with flame proof, non-drip, non-volatile adhesive (Minimum Merv 8).
   2. Holding Frames: 18-gauge galvanized steel frame with expanded metal grid on leaving air side and steel rod grid on entering air side, hinged with pull and retaining handles.
   3. Limit filter velocity, based on gross area, to maximum 400 ft/min.

2.10 FINISHES

A. External unit surfaces will be factory cleaned prior to finishing or shipping.

B. Paint unit using manufacturer’s standard color as follows:

   1. Painted units will be prime-coated prior to painting.
   2. Paint will be acrylic polyurethane.
   3. Painted unit will exceed 500-hour salt spray test, with (5%) solution, without any sign of red rust when tested in accordance with ASTM B-117.

2.11 PLENUM SECTION

A. Plenum section shall be provided and properly sized for inlet and/or discharge airflow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.

2.12 ACCESS SECTION

A. Access section shall be provided for access between components.

2.13 SECTION ACCESSORIES

A. Provide hinged doors with cam locks on all access doors of units.

B. Provide factory wired, externally switched, LED lights within sections designated on plans. Field wiring shall consist of separate 120 volt circuit to power unit lighting.
C. Provide viewing windows in access doors of sections designated on plans.

PART 3 - EXECUTION

3.1 METHOD OF INSTALLATION

A. Install units as indicated, and in accordance with manufacturer’s installation instructions.

3.2 TESTS AND INSPECTIONS

A. Fan skid will be run-balanced at specified speed to insure smooth, operation.

1. Constant volume fan assemblies will be balanced at design RPM.
2. Filter-in measurements will be taken in horizontal and vertical axes on drive and opposite-drive sides of fan shafts.
3. Filter-out measurements will be taken in horizontal, vertical, and axial axes on drive and opposite-drive sides of fan shafts.
4. Constant speed fan vibration limits: filter-in measurements will not exceed 4 mils. Filter-out measurements will not exceed 6 mils in horizontal and vertical axes, and 7 mils. in axial axis.

3.3 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

3.4 EXTRA MATERIALS

A. Provide one extra set(s) of filters for each unit as shown on project schedule

END OF SECTION 237313
SECTION 238220 - FAN-COIL UNITS AND UNIT VENTILATORS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Unit heaters
B. Cabinet heaters
C. Fan-coil units
D. Unit ventilators

1.2 RELATED DOCUMENTS

A. Air Movement and Control Association, Inc., AMCA:
   2. Guide 16: Steam and Hot Water Unit Heaters Installation/Maintenance.

B. Air Conditioning and Refrigeration Institute, ARI:
   3. Standard 440: Room Fan-Coil Air Conditioners.
   4. Standard 445: Room Air Induction Units.

C. American Gas Association, AGA.
   1. American National Standards Institute, ANSI Z83.6 and Z83.6a: Vented Infrared Radiant Heater.
   3. Underwriters Laboratories, UL 883: Safety Standards for Fan-Coil Units and Room Fan Heater Units.

1.3 QUALITY ASSURANCE

A. Provide electrical components for terminal units listed and labeled by Underwriters Laboratory.

B. Provide heating terminal units which are Institute of Boiler and Radiator Manufacturers performance rated with affixed I=B=R Insignia.

1.4 SUBMITTALS:

A. Submit in accordance with Division 1, Section 01300.

B. Product Data: 
1. Submit manufacturer’s specifications showing dimensions, capacities, ratings, performance characteristics, gauges and finishes of materials, and installation instructions.

2. Submit schedules of radiation heating elements and enclosures indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat to actual heat output provided.

C. Shop Drawings

1. Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.

2. Show mechanical and electrical requirements.

PART 2 - EQUIPMENT

2.1 GENERAL

A. Base radiation and convector capacities on 65° F. entering air temperature, 180° F. average water temperature.

B. Base unit heater and fan-coil capacities on 65° F. entering air temperature, 180° F. entering water temperature.

C. For each convection type heating unit not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet grille.

D. Where group of rooms is zoned on 1 thermostat, provide dampers on heating units in each room.

E. For inaccessible valves, provide factory-made permanently-hinged access doors, 6-inch x 7 inch minimum size; integral with cabinet.

F. Paint portion of unit visible through discharge opening with flat black enamel.

2.2 WALL/CEILING HEATERS

A. Furnish and install electric forced air heaters where specified. The heater shall be constructed of 18-gauge steel front grill. The rough-in dimensions are 9.25" wide x 12.125" high x 3.625" deep. Finish shall be a durable powder coated paint. Finish shall be white or ivory.

B. The heaters shall have a 1060-rpm fan motor, which drives a vane axial fan blower to deliver 100 cfm airflow. The heating element shall be sealed tubular type with multiple wattage taps for field conversion from highest rated wattage to lowest rated wattage. Heaters shall have standard manual reset thermal limit safety switch. Heaters shall have a fan purge limit to dissipate residual heat on heater shut down. Provide thermostat, disconnect, and relays.

C. Heater shall be designed for recessed or surface mounting installation. They may be wall mounted or ceiling mounted. Refer to on-drawing schedule. Minimum clearance from
heater to adjacent wall or floor is 6 inches. The heaters must be installed with wall box (surface or recessed).

D. Refer to plans for wattage of heater.

2.3 UNIT HEATERS:

A. Provide unit heaters in locations indicated, and of capacities, style, and having accessories scheduled.

B. Materials

1. Unit heater casings shall be constructed of steel, phosphatized inside and out, and finished with baked enamel. Motor-mounted panel shall be minimum 18-gauge steel.
2. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for 4-way air diffusion.
3. Fans shall be constructed of aluminum and shall be factory-balanced. Provide fan inlet orifice, smooth, and drawn into casing back panel.
4. Coils shall be plate-type with aluminum fins, mechanically bonded to copper tubes. Coils shall be acceptable for steam or hot water applications as scheduled.

C. Manufacturers

1. Dunham-Bush, Inc.
3. Sterling Radiator
4. Trane Co.
5. Wing Co., Div. Wing Industries, Inc.

2.4 CABINET HEATERS:

A. Provide cabinet heaters having cabinet sizes and in locations indicated, and of capacities, style, and having accessories scheduled.

B. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.

C. Motors shall be provided as specified under Section 15010 and as specified herein. Motors shall be shaded pole type with integral thermal overload protection, and motor cords for plug-in to junction box in unit.

D. Insulate front panel over entire coil section.

E. Materials

1. Chassis shall be galvanized steel wrap-around structural frame with edges flanged. Each unit shall be insulated with faced, heavy density glass fiber insulation. Cabinet shall be constructed with 16-gauge removable front panel, 18 gauge top and side panels.
2. Water coils shall have 5/8-inch seamless copper tubes mechanically bonded to configurated aluminum fins. Coils shall be designed for 300 psi and leak tested at 300 psi under water. Provide same end connections for supply and return.
3. Steam coils shall have 1-inch seamless copper tubes mechanically bonded to configurated aluminum fins designed for 75 psi and leak tested at 450 psi under water. Provide cast-iron headers, and same end connections for supply and return.

4. Fans shall include centrifugal, forward-curved double width fan wheels constructed of non-corrosive, molded, fiberglass-reinforced thermoplastic material. Fan scrolls shall be constructed of galvanized steel.

F. Accessories

1. Wall Boxes: Aluminum with integral eliminators and insect screen
2. Provide access door on coil connection side
3. Cabinet parts, cleaned, bonderized, phosphatized, and flow-coated with baked-on primer
4. Each unit shall be provided with 1-inch thick throw-away type filters in fiberboard frames
5. Recessing Flanges: 18-gauge steel flanges for recessing cabinet heaters into wall or ceiling
6. Sub-bases: 18-gauge steel sub-base for vertical units, height as indicated
7. Extended Oilers: Plastic motor oiler tubes extending to beneath top discharge grille

G. Manufacturers

1. Raywall
2. Marley
3. Berkco
4. McQuay Group, McQuay-Perfex, Inc.
6. Trane Co.

2.5 FAN-COIL UNITS

A. System Description

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

B. MANUFACTURERS: Subject to compliance with requirements, provide products by the following:

1. Daikin / McQuay International
2. Trane Company
3. Carrier
4. JCI
5. Zehnder
6. Envirotec
C. **Coil Section Insulation:** 1-inch thick, matte-finish, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. **Fire-Hazard Classification:** Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. **Airstream Surfaces:** Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. **Main and Auxiliary Drain Pans:** Plastic. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004. Drain pans shall be removable.

E. **Chassis:** Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. **Cabinet:** Steel with baked-enamel finish in manufacturer’s standard paint color as selected by Architect.

1. **Vertical Unit Front Panels:** Removable, steel, with polyethylene discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
2. **Horizontal Unit Bottom Panels:** Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped grilles.
3. **Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. **Filters:** Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. **Pleated Cotton-Polyester Media:** 90 percent arrestance and 7 MERV.

H. **Hydronic Coils:** Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 300 psig and a maximum entering-water temperature of 200 deg F. Include manual air vent and drain valve.

I. **Steam Coils:** Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).

J. **Electric-Resistance Heating Coils:** Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

K. **Fan and Motor Board:** Removable:

1. **Fan:** Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. **Motor:** ECM motor with integral thermal overload protection.
3. **Wiring Termination:** Connect motor to chassis wiring with plug connection.
L. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

2.6 UNIT VENTILATORS

A. Provide unit ventilators having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories scheduled.

B. Include in basic unit cabinets, dampers, fanboard assembly, motors, and coils.

C. Provided motors as specified under Section 15010 and as specified herein. Motors shall be split-phase-start type, capacitor-run constant speed motors.

D. Unit shall have pipe access openings in bottom of each end pocket and pipe chase across back of unit for cross-over piping and wiring.

E. Dampers shall be dual-blade mixing dampers for modulation of return and outside air. Provide sealing device on damper edges and ends.

F. Fan board assembly shall include fans, fan housings, bearings, and fan shaft. Fan board shall be 12 gauge and shall be mounted on rubber isolators.

G. Materials

1. Cabinets shall be constructed from 14-gauge furniture steel with exposed edges rounded. Units shall be provided with removable front.

2. Cleaned, phosphatized, and flow-coated with baked primer paint steel surfaces; and finished with baked enamel, standard color as selected.

3. Continuous heavy steel bars welded in place for discharge grilles, integral with unit structure.

4. Coils: Hydronic and steam coils shall have 5/8-inch copper tubes with plate-type aluminum fins.

H. Refrigeration:

1. Direct expansion coils of 2 row copper tubes and aluminum fins, conforming to ARI 210.

2. Factory-installed thermal expansion valve, refrigerant filter-drier, and R-22 holding charge.

3. Condensing units equipped with built-in suction line accumulator, anti-slugging devices, crankcase heater, filter-drier, winding thermostat, current overload protection, pressure limiting valve, and electrical control panel.

4. Equip with sweat connection special adapters, service valves, and sight glass.

5. Provide start-capacitor kit.

I. Accessories:

1. Filters: 1-inch thick throw-away filters in both outside and return air streams

2. Wall Louvers: For outside air intake, vertical blade design, constructed of heavy gauge aluminum
3. Cross-over Piping: Provide in cabinet pipe chase, of size and configuration indicated on Drawings
4. Auxiliary Radiation: Finned tube radiation with enclosures to match unit ventilator cabinets
5. Completely removable end panels for access to piping and valves
6. Provide leveling legs

J. Manufacturers

1. American Air Filter Co., Inc.
2. Trane Co.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install units as indicated, and in accordance with manufacturer’s installation instructions.

B. Provide each unit with shut-off valve on supply and lockshield balancing valve on return piping.

1. Accessibility:
2. Provide each unit with easily accessible manual air vent at high points.
3. When not easily accessible, extend vent to exterior surface of cabinet for easy servicing.
4. For fan-coil units and unit heaters, provide float-operated automatic air vents with stop valve.
5. Locate each unit accurately in position indicated with sufficient clearance for normal service and maintenance, including clearance for enclosure removal.

C. Support hanging units from structure as detailed on Drawings.

D. Level or pitch units and elements to indicated tolerance; shim.

E. Install fan coil units to comply with NFPA 90A.

F. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 “Vibration and Seismic Controls for HVAC Piping and Equipment.”

G. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect condensate drain to indirect waste.
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a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 INSPECTION

A. Comb out damaged fins where bent or crushed, before covering elements with enclosures.

B. Clean dust and debris from each unit as it is installed.

C. Touch-up finish on each cabinet and component after final adjustments are made.

D. Install new filter units for terminals requiring same.

E. Replace heating elements which have excessively damaged fins and replace enclosures and accessories which are damaged beyond restoration to acceptable condition.

3.4 FIELD QUALITY CONTROL

A. Repair or replace terminal equipment to eliminate leaks, following purging and tightness testing of piping, and retest by specified method to demonstrate proper performance.

B. Flush system before opening stop valve to hydrostatically test fan-coil units

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

END SECTION 238220
SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves for raceways and cables.
   2. Sleeve seals.
   4. Common electrical installation requirements.

1.2 SPECIFICATION FORM AND DEFINITIONS

A. Design Engineer, hereinafter abbreviated D/E shall mean the Engineering firm, Olsson, 1301 Burlington St, Suite 100, North Kansas City, MO, Telephone (816) 361-1177. Contact person: Tim Danner.

B. All drawings and specifications on the project are complementary, each to all other sets, and they shall be used in combination for the execution of this work. Division 26 work shown on any one set of drawings, including all Architectural drawings for general work and equipment, and Division 26 work called for under any section of the project specifications, shall be considered as included in this work unless specifically excluded by inclusion in some other branch of the work. This shall include roughing-in for connections and equipment as called for or inferred. The Contractor shall check all drawings and specifications for the project and shall be responsible for the installation of all Division 26 work.

C. The contract drawings for Division 26 work are in part schematic, intended to convey the scope of work and indicate the general layout, design and arrangement. The Contractor shall follow these drawings in the layout of his work and shall consult general intent construction drawings, structural drawings mechanical drawings and all other drawings for this project to determine all conditions affecting the Division 26 work. The contract drawings are not to be scaled and the Contractor shall verify spaces and conditions in which the Division 26 work is to be installed.

D. Where specific details and dimensions for Division 26 work are not shown on the drawings, the Contractor shall take measurements and make layouts as required for the proper installation of the work and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications that have not been clarified by addendum prior to bidding, it shall be assumed by the signing of the contract that the higher cost (if any difference in costs) is included in the contract price, and the Contractor shall perform the work in accordance with the drawings or with the specifications, as determined and approved by the Architect, and no additional costs shall be allowed by the contract price.

1.3 WORK INCLUDED

A. This work shall include all plant, labor, material and equipment as required to furnish and install Division 26 work as shown on drawings and as hereinafter specified. Work shall also include all plant, labor, material and equipment not shown on drawings and not specified but necessary and reasonably incidental to comply with the intent of contract to provide first class and complete installations of Division 26 work. Furnish and install all materials,
equipment, devices, and accessories not specifically called for by item but that are necessary to provide the requirements in operation and function that is established by the design and by the equipment specified.

B. Work shall also include:
1. The procurement of and payment for all permits and licenses required for the performance of the work;
2. All fees and direct expenses involved in any inspections required for the project;
3. All hoists, scaffolds, staging, runways, and equipment required for the performance of the work.
4. All job measurements and shop layouts required for the proper installation of material and equipment included in the work.
5. All lights, guards, and signs as required by safety regulations applicable to the work;
6. The removal from the premises, as it accumulates, of all dirt and refuse resulting from the performance of the work;

C. Work shall include providing labor and equipment for current and voltage readings, and adjustments required on Division 26 equipment for testing and balancing of mechanical systems as specified in, Division 22 and 23 of this specification.

D. Electrical work includes, but is not limited to:
1. Meters, switchboards, panelboards, circuit breakers, power outlets, convenience outlets, switches, and/or other equipment forming part of system;
2. Connection of all appliances and equipment including Owner furnished equipment;
3. Complete normal and egress lighting and power system, including:
   a. Individual battery units
4. Complete fire alarm system.
5. Complete temporary facilities for construction power.
6. Additional requirements as reasonably indicated by the drawings

1.4 SHOP DRAWINGS AND SAMPLES

A. Acceptance of the work shall be subject to the Architect's approval of shop drawings, product data and samples. Shop drawings shall include manufacturer's detail drawings of equipment and material and Contractor's shop drawings of equipment and material and Contractor's shop details for installation of material and equipment. Descriptive literature shall include catalog data covering design, size and capacity of material and equipment. Samples shall be parts or complete units of material and equipment made available for inspection by the Contractor. Samples shall be as requested by the Architect.

B. Submittals shall include the manufacturer's model number, capacity, performance data, electrical characteristics, etc., all clearly shown and marked for the specific item of equipment to be furnished on this project. General catalog data that does not indicate the specifics for the item to be furnished for this project will not be accepted. Performance data shown or marked on the submittals shall be at the actual specified operating conditions for this project.

C. The Contractor shall, prior to forwarding shop drawings to the Architect, review all shop drawings, check all conditions and make all corrections and sign and date each set. No shop drawings will be reviewed by the Architect without signature of Contractor which will signify that he has checked drawings.
D. When Shop Drawing submissions are in the form of portable document format (PDF), they shall be transmitted via email to the contact information provided during the pre-construction conference. Each submittal transmitted in PDF format shall include only one specification section. Multiple specification section submittals combined into one singular PDF file will not be accepted. The cover page of the submittal shall include all necessary information for proper identification of project, submittal, and date, and shall include a blank area, minimum 4-1/4” by 5-1/2” in size, for placement of the engineer’s review stamp. The email transmittal and PDF file naming shall be compliant with the following guidelines:

1. Email submittals to be addressed to: TBD, as instructed during pre-construction conference.
2. Email subject line shall include the following information, in order of listed below and separated by dashes:
   a. “SUBMITTAL”
   b. Project Number (as listed in titleblock and specifications).
   c. Specification Section Number
   d. Specification Title
   e. “FOR REVIEW”
   f. Example: “SUBMITTAL-16076.1-230523-HVAC Valves-FOR REVIEW”
3. The PDF file for the actual submittal shall be compliant with the following guidelines:
   a. Project Number (as listed in titleblock and specifications).
   b. Specification Section Number
   c. Sequence Number (separated from section number by a ‘dot’). In the case of a resubmittal, the sequence number shall remain the same as the previously submitted file, and shall be
   d. Specification Title
   e. “FOR REVIEW”
   f. Example: “16076.1-230523.01-HVAC Valves-FOR REVIEW.pdf”.
4. Failure to follow email transmittal or document naming guidelines will result in an automatic rejection of submittal.

E. Other requirements for shop drawings shall be as specified in the "General Conditions" of these specifications, and in each appropriate specification section.

1.5 RECORD DRAWINGS

A. The Contractor shall keep a day-to-day record of all changes or variations made from the contract drawings and at the end of the project shall obtain reproducible mylars, at the Contractor’s cost, of the original contract drawings for Division 26 work and show all changes from the original plans made during the installation of his work. Any reference to Addendum and Change Orders shall be deleted from mylars. Drawings shall indicate but not be limited to the following:

1. The correct location of lighting fixtures, feeder conduits, and other equipment where it differs from the location shown on the drawings
2. The location of all switches, receptacles, security devices, panelboards, junction boxes, etc.
3. Any other information of a pertinent or useful nature
4. Any change order items not issued on supplementary drawings

B. All notations shall be made in a neat and legible manner with any additional explanatory drawings or sketches necessary.

C. The complete set of Record Drawings shall be delivered to the Architect at the completion of the work. Final payment will not be made until Record Drawings are received.

1.6 MATERIAL AND MANUFACTURE

A. All material and equipment shall be new except as stated otherwise; shall be of the best quality and design; shall be free from defects and imperfections and shall have markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. As possible, all material and equipment of the same type shall be of the same manufacturer. Equipment shall function and perform efficiently and quietly at the required capacity without producing objectionable noise within the occupied areas of the building; if not, the Contractor shall remedy the condition or replace the equipment at no additional cost to the contract.

1.7 SUBSTITUTIONS

A. Reference in the specifications to any article, device, product, material, fixture, equipment, form or type of construction by name, make or catalog number shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. Any article, device, product, material, fixtures, equipment, form or type of construction other than those specified may be substituted, in accordance with the preliminary matters, general conditions, supplemental conditions applicable unless otherwise specified if in the opinion of the Architect, it is equal in every respect to that specified.

B. All products proposed for use, including those specified by required attributes and performance shall require approval by the Architect before being incorporated into the work. Do not substitute materials, equipment, or methods unless such substitution has been specifically approved for this work by the Architect. Approved substitutions for proprietary materials and systems will be considered, however, approval must be requested prior to use. Burden of proof of equal quality, appearance, performance, and utility rests with the Contractor. Submit technical data and other pertinent information to the Architect.

C. Where the phrase "or equal" or "approved equal" occurs in the contract documents, do not assume that materials, equipment, or methods will be approved as equal unless the item has been specifically approved for this work by the Architect/Engineer. The decision of the Architect/Engineer shall be final.

D. Where indirect lighting systems have been specified on the drawings or hereinafter the Contractor shall be responsible for providing to the Owner and the Architect all supporting calculations, dimensional data, detailed layouts, samples, etc. for consideration prior to bidding. This information shall reach the Architects office no later than 7 days prior to the bid date. Lighting systems that do not meet the criteria specified hereinafter under Section 265100 will not be considered as an approved equivalent.
1.8 LABOR, WORKMANSHIP, AND SUPERVISION

A. All labor for the installation of material and equipment furnished under the Division 26 work shall be done by experienced mechanics of the proper trade and all workmanship shall be first class and in compliance with the specific requirements of drawings and specifications.

B. All material and equipment for the Division 26 work shall be installed under competent supervisory service furnished by the Contractor. Where necessary, this shall include the services of special erection and operation personnel.

1.9 SAFETY REGULATIONS

A. All Division 26 work shall be performed in compliance with all applicable and governing safety regulations including the regulations of the Occupational and Safety Health Act. All safety lights, signs and guards required for performance of Division 26 work shall be provided by the Contractor.

1.10 PERMITS AND LICENSES

A. All permits and licenses that are required by governing authorities for the performance of Division 26 work shall be procured and paid for by the Contractor.

1.11 CODES, ORDINANCES, REGULATIONS, AND U.L. APPROVAL

A. All Division 26 work shall conform to the requirements of all applicable codes, ordinances and regulations including the current rules and regulations of the [National Electrical Code], the [National Fire Protection Association], O.S.H.A. and all state and local laws, codes and ordinances.

B. Laws, codes, ordinances and regulations shall take precedent excepting only where the work called for by the drawings and specifications exceeds by quality and quantity.

C. Fixtures, appliances, equipment and materials which are subject to Underwriter’s Laboratory tests shall bear such approval.

1.12 CONTRACTOR’S EQUIPMENT

A. All hoists, scaffolds, staging, runways, tools, machinery and equipment required for the performance of the Division 26 work shall be furnished by the Contractor.

1.13 COORDINATION AND COOPERATION

A. The Division 26 trades shall cooperate and confer with all other trades on the project, as to locations of their materials and equipment before erecting the work so as to avoid interference and delay in progress of construction. In instances where interference may develop, the Contractor shall relocate his work as approved by the Architect, to depart from such interferences at no additions to the contract price. Where it is necessary to make adjustments in the locations or routing of conduits, wireways, or other installations (from that shown-on drawings) to clear obstructions or other installed work, the Contractor shall be responsible for making these adjustments as a part of the contract work.

B. The Contractors shall coordinate with the Owner’s designated Representative as to scheduling his work in all areas and shall obtain approval from the Owner’s designated Representative prior to any disruption of services or activity. All shut down of services shall be maintained to a minimum.
1.14 STORAGE AND PROTECTION

A. Material and equipment for the Division 26 work shall be protected from dirt and damage and maintained in a clean condition during the performance of the work. This shall include adequate protection from the weather if storage is outside. All parts of material and equipment that have become rusted or damaged shall be replaced or restored to an acceptable condition as approved by the Owner's designated Representative. This shall include factory finishes damaged during construction. Any refinishing shall be spray painted, brush applied paint will not be acceptable.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.
   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

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

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
2.4 EQUIPMENT FURNISHED BY OWNER OR OTHER TRADES

A. Equipment furnished by other trades includes the following:
   1. Mechanical Pumps, air handling units, terminal units (installation by M/C, wiring by E/C)
   2. PLC cabling, devices, transmitters, sensors
   3. VFD where indicated on drawings to be packaged with HVAC equipment (furnished by HVAC, installed by E/C).

B. The Contractor shall be responsible for coordinating with the manufacturer for installation of the equipment furnished above, as shown on drawings. The Contractor shall be responsible for warranty work required and shall coordinate with the manufacturer of the equipment to accomplish warranty work including any labor and additional cost for such warranty work. The Equipment Manufacturer shall provide the Contractor with installation manuals and instructions. The Contractor shall receive and install this equipment for a complete installation including all accessories as specified within these specifications and as shown on drawings.

C. The Contractor shall check equipment and trim delivered to job site by Equipment Supplier against approved shop drawings or other required documentation. The Contractor shall report all discrepancies, shortages, or lack of data to the Owner and Equipment Supplier for adjustments within 1 week after equipment is received. If such report is not made within one week, it shall be assumed no discrepancies, shortages, or lack of data has been found.

D. The Contractor shall be responsible for the installation of, interfacing with, and connection to equipment in order to ensure complete and operating systems.

2.5. PRE-CONSTRUCTION ELECTRICAL INSTALLATION CONFERENCE

A. The contractor shall schedule and coordinate a pre-construction electrical installation conference attended by the Owner’s representative and the Engineer. The purpose of this conference is to provide an overview of the contract requirements, drawings and specifications. The contractor shall be responsible for recording and distributing the minutes of the conference. Schedule this conference within 14 calendar days of the receipt of Notice to Proceed.

2.6. MANUFACTURER’S STANDARD PRODUCTS

A. It is the intention of these contract documents, drawings and specifications, to require manufacturers’ standard products, equipment, components and accessories to complete the work.

B. The equipment, components and accessories furnished by the Contractor shall be the manufacturer’s standard, off-the-shelf products as modified only by the manufacturer’s standard options and accessories. Do not provide prototypical equipment, components and accessories when standard, off-the-shelf products are available. Standard products that do not meet these specifications shall not be custom-manufactured or otherwise modified to meet the specifications but shall be rejected.

C. The Engineer shall make the final determination whether standard, off-the-shelf products are available, and whether any given product is the manufacturer’s standard product.

D. The products of approved manufacturers meet the intent of these specifications.
2.7. MOTORS, CONTROLS, AND OTHER EQUIPMENT

A. Except as otherwise specified, the Division 26 work shall include receiving, installing and mounting all detached motors, switches, motor control equipment and other control devices furnished under other divisions of work. Contractor shall check all headings of specifications for equipment to be installed. Work shall include mountings and supports as required for all equipment, including angle frames, steel plates, bars, bolts, etc., and all conduit, wire, etc., as required to connect all equipment including motors, disconnect switches, starters, controls, push-buttons, etc. Detached motors shall be set and aligned with coupling or drive. Motor connections shall be terminated with unexposed leads in suitable conduit and cover. Conduit shall terminate close to motor with a minimum of 12" of flexible liquid tight conduit between rigid conduit or EMT and motor.

B. Unless specified otherwise, perform all work required to rough-in and connect to all equipment requiring electrical connections. This work shall be as indicated on drawings, by approved equipment shop drawings and by direction on the job as approved by the Architect.

C. All equipment, materials or devices furnished by others including that furnished by the Owner or under any other division which required electrical connections shall be roughed-in and connected under this division, unless specified otherwise. It shall be the Contractor’s responsibility to verify exact requirements for rough-in and connection of equipment furnished by others prior to installation. Extras will not be allowed for failure to verify rough-in and connection requirements.

D. The Contractor shall run feeders to starters, disconnects, control panels and motors as shown on drawings, make connections, and install and wire all mechanical components in accordance with wiring diagrams furnished under Division 22/23 work. The Contractor shall coordinate with any other trades involved for the proper coil voltages for control of magnetic starters and contactors.

E. Unless otherwise specified or shown on the drawings, control wiring and connections for temperature control systems shall be as specified under Division 22 and 23

2.8 ADJUSTING, ALIGNING, AND TESTING

A. All electrical equipment furnished under this Division shall be adjusted and tested by this Contractor. Motors and other equipment furnished by others, to which electrical connections are made under this Division, shall be checked for short circuit and open circuits before energizing. Motors shall be checked for proper phasing and rotation. The thermal overload protection devices shall be checked in all motor starters, and equipment and all protection device size, motor nameplate full load amperage, and voltage rating for protection of the motor shall be listed (include equipment designation, rating of heater, motor nameplate horsepower, full load amps and voltage) and 4 copies of list shall be submitted to the Architect.

B. Mechanism of all electrical equipment shall be checked, adjusted and tested for proper operation. Protective devices and parts shall be checked and tested for specified and required application and adjusted as required. Adjustable parts of all lighting fixtures and electrical equipment shall be checked, tested and adjusted as required to produce the intended performance.

C. Completed wiring systems shall be free from short circuits and after completion, perform tests for insulation resistance in accordance with the requirements of the National Electrical Code.
D. The Contractor shall be held responsible for the operation, service and maintenance of electrical equipment during construction and prior to acceptance by the Owner. All electrical equipment shall be maintained in the best operating condition. Operational failure caused by defective material an/or labor furnished under this Division shall be immediately corrected. Architect shall be immediately notified of any operational failures caused by defective material and/or labor covered under other Divisions or furnished by others.

2.9 ELECTRICAL CIRCUITRY FOR EQUIPMENT

A. The electrical circuits, components, and controls for all equipment are selected and sized, based on the equipment specified. If substitutions and/or equivalent equipment are furnished, it shall be the responsibility of all parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to verify and compare the electrical characteristics and requirements of that furnished to that specified and/or shown. If greater capacity or more materials or labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then it shall be the responsibility of the parties involved in providing the substitute and/or equivalent items of equipment to provide all compensation for additional charges made for the proper rough-in, circuitry and connections for the equipment furnished. No additional charges above the Base Bid shall be allowed for such revisions.

B. Before rough-in of circuitry or connecting to equipment, the Contractor shall verify the electrical characteristics and requirements of the equipment being furnished, and for that specified and shown on drawings.

2.10 CLEARANCES

A. All electrical equipment shall be so installed to maintain proper clearance and head-room as required by the National Electrical Code.

2.11 CUTTING AND PATCHING

A. The responsibility for any cutting of construction which is required for the installation of Division 26 work, shall be by the Contractor. The Contractor shall coordinate with all other Contractors and the Owner before any cutting and obtain approval from the Architect prior to any cutting. All patching and finishing shall be by the Contractor.

B. Cutting shall be done with extreme care and in such a manner that the strength of the structure will not be endangered. Wherever possible, openings in concrete or masonry construction shall be by concrete saw or rotary core drill. Openings in any construction shall be cut the minimum size required for the installation of the work. Adequate protection shall be provided to prevent damage to adjacent areas and to prevent dust from spreading to adjacent areas.

C. Before any cutting, patching, or finishing work is started, dust and moisture protection shall first be installed as specified.

D. Openings cut in floor shall be cut by core drilling where possible. After work is installed through any opening in floor, the opening around the work shall be patched and sealed watertight and epoxy or silicone based, non-cracking elastomeric sealant.

E. Contractors bidding on this project shall coordinate prior to bidding all cutting requirements under this division with the General Contractors for patching requirements to be included in their bids. See Division 1 of the specifications for additional requirements.
F. Unless otherwise noted, x-ray concrete slabs, walls, etc., to locate rebar. X-ray equipment used shall include protective shielding to prevent any harmful radiation from being transmitted to surrounding working equipment. Submit complete diagram of x-ray set up and predicted radiation disbursement for review.

2.12 OPENINGS IN FIRE RATED ASSEMBLIES

A. Where openings are made or left due to demolition through fire rated assemblies for conduit or nipples, for sleeves containing cable or wire, and for open conduits through rated assemblies the area around openings, sleeves, and conduits shall be fire stopped as specified below. The area around conduits or nipples and unused openings shall be sealed and finished to match adjacent surface prior to opening. Voids up to ½" wide around conduit penetrations shall be sealed with fire resistant foam sealant as specified.

B. Where the conduit or nipple is left unused for use by others, install a pipe cap on end of raceway on each side of wall or floor.

C. Electrical boxes in fire rated walls shall be fireproofed around with Monocoat fire proofing compound as manufactured by W.R. Grace. The electrical boxes shall be completely covered with a thickness as recommended by the manufacturer and as approved by the authority having jurisdiction. Submit shop drawings on material and recommended installation.

2.13 ROOF PENETRATIONS

A. All openings in the roof for electrical conduits shall be made weather and watertight using "Stoneman" multi-flash or versa-flash seamless flashing assembly for conduit sizes through 2 inches. Conduit sizes over 2 inches shall have pitch pockets filled with pitch and galvanized drip shield installed around conduits. The drip shield shall completely cover pitch pocket.

2.14 EXCAVATION AND BACKFILLING

A. Perform all excavating and backfilling necessary for the construction and installation of the work included under this Division. Lines shall be used to layout the trenches for all underground work and there shall be no variation from the drawings except upon written order from the Architect. Trenches close to walls, foundations, and columns shall not be excavated without prior consultation with the Architect or his Representatives.

B. All excavations shall be properly protected by the necessary bracing and timbers to prevent any cave-ins or injury to adjacent improvements. Where required to prevent caving, the sides of the trenches shall be securely held by bracing or sheathing, which bracing or sheathing shall not be removed until the level of the backfill has reached the point where such removal can be safely carried out. Where adjacent improvements might be damaged by the removal of such bracing, the braces shall be left in place to prevent such damage. The thickness of the sheathing and the dimensions of the cross braces, shoes and miscellaneous supports to be used by the Contractor shall be as required and of type to properly protect the sides of the trench and to prevent injurious cave-ins or erosions.

C. Perform all pumping and bailing necessary to keep all excavations free of water and provide for the uninterrupted flow of the surface water adjacent to the line of work during the progress of the work. Inspect the ground where excavation is required to ascertain the structure of the soil.
D. In cases where water, sewer, gas, electric or other pipes or conduits are encountered, they shall not be displaced or molested unless necessary, in which case, they shall promptly be replaced in good condition. All water, sewer, gas, conduits, or electric lines damaged or molested in the construction shall be replaced or repaired at the Contractor’s expense. Prior to opening an excavation, every effort shall be made to determine whether underground installations will be encountered (by examining all available records, by explorations, by hand excavations, by carefully probing, and all other means), and if so, where underground installations are located. When the excavation approaches the approximate location of the underground installations, they shall be carefully uncovered (by hand excavation where required) and shall be protected from damage after uncovering. All known Owners of underground facilities in the area concerned shall be notified of the proposed work at least 48 hours prior to the start of excavation.

E. Provide all temporary bridges, barricades, lanterns and such other signs and signals as shall be necessary to warn the public of the dangers caused by excavations and other obstructions.

F. The backfilling of trenches shall be carried out as rapidly as the finished work is approved and will permit. The trench shall be backfilled in layers not to exceed 6” with good selected dry earth thoroughly tamped with pneumatic tamper. Note: Broken stones, cinders, frozen earth and rubbish are not acceptable for backfilling.

G. After backfilling, all surplus excavated material shall be removed from the grounds.

H. The work shall be executed so that existing culverts, drains, catch basins, retaining walls, fences or any other permanent structure along and adjacent to the new work are properly protected. Any damage occurring to these structures shall be repaired by the Contractor at his own expense.

I. Make a field inspection of the location along which the underground work is to be constructed and note all obstructions and improvements at the surface and overhead which may affect the method of operation. Such obstructions which may be existing, or which may be encountered shall be protected by the Contractor during this construction. Any expense or inconvenience caused by their existence, and the necessary protection required, shall be considered as covered and included in the contract, without additional cost to the Owner.

J. Materials to be excavated are not classified under the base bid. Excavation work shall include the removal and subsequent handling of earth, clay, shale, loose rock, solid rock, debris or any other materials encountered within the limits of the work required by the drawings and specifications to the elevations indicated.

K. Blasting - Blasting will not be permitted.

2.15 ACCESS PANELS

A. The contractor shall furnish all access panels for walls, partitions, etc., and shall give access panel to the General Contractor for installation at locations as directed by the Electrical Contractor.

B. It shall be the responsibility of the Electrical Contractor that access panels are provided for access to all boxes, bus joints, equipment, etc., which may be concealed by building construction to comply with the NEC and NFPA.
2.16 ANCHORS

A. Provide anchors for all equipment, raceways, hangers, etc. to safely support weight of item involved plus 100% for dead loads. Live loads shall be considered in addition to dead loads.

B. Anchors to consist of expansion type devices similar to "Redhead" or lead expansion anchors. Plastic anchors are not acceptable. Protect telephone equipment from drilling residue. Powder actuated "shot" type anchors are not allowed.

C. Use preset anchor steel inserts in concrete slabs. Provide preset anchor size and type for anticipated or specified rod/bolt size and live/dead load.

2.17 HOUSEKEEPING PADS

A. Furnish 2500 # concrete pads, 4" high, unless otherwise noted, for all freestanding equipment, i.e.: switchgear, panels, control panels, integrated panel center, transformers, etc. Pads shall have 1" x 45° chamfered edges and shall extend 4" beyond equipment mountings.

PART 3 - EXECUTION

3.1. CLEANING

A. Dirt and refuse, resulting from the performance of the work shall be removed from the premises daily as required (broom clean) to prevent accumulation and the Contractor shall cooperate in the maintaining of reasonably clean premises at all times.

B. Immediately prior to the final inspection, Contractor shall clean all material and equipment. Dirt, refuse and stains shall be removed from all surfaces and damaged finishes restored to original condition.

3.2. NOISE AND VIBRATION

A. Contractor shall be responsible for the installation of all equipment in such a manner as to control the transmission of noise and vibration from any installed equipment or system, so the sound level shall not exceed NC35, in any occupied space. Contractor shall be responsible for the correction of any objectionable noise in any occupied area due to improperly installed equipment.

3.3. OPERATION AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall furnish all services as required for adequate verbal and printed instructions to the Owner and the Owner's operating and maintenance personnel for operation and maintenance of all equipment and systems installed under this Division. Three complete copies of service manuals in hardback binder shall be furnished at the end of the project in accordance with the General Conditions of the specifications. The manuals shall include printed operating and maintenance instructions for systems and
equipment specified under this Division, all approved shop drawings and all manufactures printed data.

1. Data to include serial numbers, catalog/model numbers, parts lists, description of operation, final shop drawings, wiring diagrams, all electrical ratings, set-up and maintenance procedures and other literature required for maintenance of equipment. See Technical Sections for other required information.

B. When the work is complete and at a time designated by the Owner's designated Representative, the Contractor shall furnish the services of a qualified instructor to instruct the Owner's personnel in the operation and maintenance of the systems and equipment.

C. The bound copies of the operating and maintenance manuals shall be used during the verbal instructions. Maintenance Manual Requirements:

1. emergency instructions including addresses and telephone numbers for service sources.
2. Regular system maintenance procedures
3. Indicate proper use of tools and accessories
4. Wiring and control diagram for each system
5. Manufacturer's data for each operational item in each system
6. Manufacturer's product warranties, and guarantee relating to the system and equipment items in the system
7. Final Shop and Erection drawings relating to the system
8. Bind each operating and maintenance manual in one or more vinyl-covered, 2" 3-ring binders, plus pocket-folders for folded drawings. Index with thumb tab collated with Table of Contents for sections. Mark the back spine and front cover of each binder with system identification and volume number.

D. Maintenance Materials: Deliver all materials to the Owner in fully identified containers or packages suitable for storage. Obtain receipt for all delivered materials signed by Owner’s Operation Manager.

3.4. WARRANTIES

A. Warranties shall be provided for all material, labor and equipment in accordance with the requirements of the General Conditions, except that all warranties shall be non-prorated for a minimum of one year, except for items requiring additional warranty as specified otherwise in other sections of this specification.

B. Acceptance of the work under this Division shall be subject to the conditions that all installed systems, equipment, apparatus, and appliances included in the work shall operate and perform as designed, including code clearances, and as selected with respect to efficiency, capacity and quietness and shall operate and perform without producing objectionable noise within occupied areas of the building.

C. Acceptance of the work shall also be subject to the conditions that any time within one year after date of final payment, any defective part of the work resulting from the supply of faulty workmanship or material shall be immediately amended, repaired or replaced as a part of the contract work without cost to the contract.

D. This Contractor shall be responsible for warranties in accordance with the above specifications, of any equipment or materials of which is preordered by the Owner and assumed and received by this Contractor.
3.5. SCHEDULE

A. The Contractor shall submit, within 15 days after notice to proceed, a schedule of work and equipment delivery for this project and a list of all major subcontractors’ electrical items with the manufacturer’s name, suppliers name and estimated date of receipt of material.

B. It shall be the Contractor's and Equipment Supplier's responsibility to make themselves aware of the schedule and submit shop drawings accordingly to achieve receipt of material and equipment on a timely schedule to meet the building ready and project completion dates.

C. The Contractor shall immediately notify the Architect if any installation problems or delivery problems are anticipated which would impede installation or scheduled completion of this project.

3.6. SAFETY AND LOCKOUT/TAGOUT PROCEDURES

A. Safety of all personnel during work performed is the responsibility of the Contractor. Working on and around electrical equipment and circuits requires more than normal precautions. Obtain checklist for lockout and tagout of all energy driven equipment from Architect/Engineer prior to construction.

3.7 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless otherwise noted.

B. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

C. 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.

D. Right of Way: Give to piping systems installed at a required slope.

3.8 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.
G. Size pipe sleeves to provide 0.25-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

I. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

3.9 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 260500
SECTION 260501- TEMPORARY ELECTRICAL FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish temporary electrical facilities to provide lighting and power for construction. Temporary power must be installed in accordance with the National Electrical Code, National Electrical Safety Code, local utility, local codes and authority having jurisdiction.

B. Coordinate temporary electrical facilities with other trades.

C. Work or cost not included in the Section:
   1. Electrical energy cost during construction period.
   2. Circuits for equipment requiring either heavy current or special voltages (Negotiate directly between this Division and other Divisions requesting special services).
   3. Circuits for exterior lighting
   4. Relocation of temporary wiring after installation
   5. Wiring not specified below.

1.2 TEMPORARY UTILITIES, SERVICES AND CONNECTIONS

A. The Contractor shall provide temporary electric power for construction purposes in accordance with all Codes and Ordinances and as required by projects. All temporary equipment, materials and connections required for the temporary services shall be furnished and installed by the Contractor. At the completion of the project or at such time as the temporary services are no longer needed, the Contractor shall remove all temporary equipment, materials, and connections and shall restore facilities to permanent finished conditions. Contractor may obtain temporary service from the existing building.

B. Temporary wiring connections and facilities shall be installed as required, so that all spaces, fixtures, devices, equipment, and circuits that are required to stay in operation do so, and so that interruptions in the use of any space, device, fixtures or piece of equipment can be held to the absolute minimum time possible.

C. Interruptions in existing utilities, services, or in the electrical circuitry and facilities shall be scheduled and sequenced, and sequencing shall conform to specific requirements as specified in other sections of the specification or as indicated on the drawings. The scheduling and sequencing shall be coordinated in advance with the Owner and Engineer and shall be as approved by these parties. Even though a schedule is approved, the Owner shall also be notified immediately prior to any interruption in any electric facilities and circuits so that alternative arrangements can be made.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide new or used materials and equipment suitable for intended use. Ensure safe, adequate performance of facilities in accordance with governing regulations. Used equipment shall be in good, safe working order.
PART 3 - EXECUTION

3.1 INSTALLATION AND OPERATION
A. Except for self-contained facilities, connect and terminate temporary electrical facilities at locations required for proper distribution.
B. Do not subject electrical facilities on either temporary work or temporary use of permanent work to excess demand or overload.

3.2 SERVICE CONNECTION
A. Obtain temporary service from Power Company. Install service in conformance with NEC 230.
B. Include charges of Utility Company for temporary service connection. Pay all "Connect and disconnect charges of Utility Company".

3.3 GROUNDING
A. Power service and distribution system shall be properly grounded in accordance with NEC requirements.
B. Ground the system neutral in accordance with NEC 250.
C. Provide feeders and branch circuits with ground wire sized per NEC 250-95. The raceway system is not acceptable as a grounding means.

3.4 POWER SYSTEM AND DISTRIBUTION
A. Provide required distribution and capacity of system. Over-current protection, fusible and/or circuit breakers sized per NEC.
B. For 120/240 volts, single phase system; use 3-wire 120/240-volt feeders and branch circuits.
C. For 120/208-volt, 3 phase, 4-wire system; use 120/208 volt balanced single phase 3-wire distribution or 120/208 volts, 3 phase, 4-wire distribution.
D. For 480-volt, 3 phase, 3-wire distribution system; use balanced 2-wire single phase or 3-wire, 3 phase feeders for step-down to 120/240 volt or 120/208-volt utilization.
E. For 277/480-volt distribution system; use balanced 2-wire single phase or 3 and 4-wire, 3 phase feeders for step-down to 120/240 volt or 120/208-volt utilization.
F. Step-down transformers inside building shall be dry-type construction; protect from weather and construction damage.
G. Use No. 12 wire for branch circuits less than 100 feet to last outlet, and No. 10 wire for circuits beyond 100 feet. Install branch circuits using NEC approved wiring methods.
H. Balance loads connected to 3 phase services within reasonable limits.

3.5 PLUG-IN RECEPTACLES
A. Use 20A, duplex, NEMA grounded type or as required for special equipment.
B. Branch circuits feeding receptacles shall be 20A or as required for special equipment.
C. Provide receptacles to be reached by 50-foot extension cord.
D. All receptacle circuits shall be protected by dynamic type ground-fault circuit interrupters, which automatically disconnect circuit when leakage current of 4-6mA is detected.

E. Receptacles shall not be placed on the same circuit with temporary lighting.

3.6 TEMPORARY LUMINARIES
A. Provide luminaries approved by NEC for temporary construction wiring.
B. Lamps shall be rough service incandescent 150 watt to 300 watt or LED 30-60 watt equipped with guards to protect from contact and damage (sizes as directed).
C. For estimating purposes, figure total number of light sockets as follows:
   1. One for every 300 sq. ft. of interior rooms
   2. One for every 750 sq. ft. of exterior rooms with windows
   3. Exterior rooms, which contain windows with room depth less than 10 feet from exterior wall require no socket. Exterior rooms more than 10 feet deep calculated by excluding exterior 10-foot bay.
   4. Fluorescent luminaries may be used at contractor’s option.

3.7 LAMPS AND REPLACEMENTS
A. Provide lamps.
B. Replace burned out lamps to maintain required lighting levels throughout the duration of the project.

3.8 INSTALLATION OF CIRCUITS
A. Install required lighting and receptacle circuits along a route least objectionable to construction work as determined by Contractor. Protect circuits where exposed to damage.

3.9 PERMANENT WIRING SYSTEM
A. Do not use permanent wiring for construction without specific acceptance of Consultant. Before using permanent wiring for temporary service, submit a list of uses to Consultant. Consultant may refuse use of permanent equipment for temporary service. Use of permanent equipment prior to Substantial Completion shall not affect warranty period.

3.10 REMOVAL AND RESTORATION
A. Temporary wiring shall be removed immediately upon completion of construction or purpose for which the wiring was installed. Repair or replace work damaged by temporary electrical facilities. Clean and restore permanent electrical system used to provide temporary services to condition of new and unused work.
   1. Electrical work installed as temporary facilities, upon removal, remains property of Installer.
   2. Replace lamps of permanent light fixtures used for temporary lighting, which have burned out or are noticeable dim. All permanently installed fixtures in the construction area lamps shall be removed and cleaned.
   3. Where temporary use of lamps exceeds 50 percent of lamp life, replace lamps.
B. At Substantial Completion, clean permanent electrical work used as temporary facilities. Remove debris accumulated in electrical spaces.

END OF SECTION 260502
SECTION 260519 – LOW VOLTAGE ELECTRICAL CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.
B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.
C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.
B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
C. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced. For conductors #8 AWG and smaller, splice and tap connectors shall be spring connectors with molded vinyl caps. For conductors #6 AWG and larger, splice and tap connectors shall be split-bolt or compression type installed with hydraulic tool of proper capacity as recommended by the manufacturer for the size of conductor on which the connector is used.
D. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
E. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer’s published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.
F. Induction motors are to be terminated with bolted pressure connections and insulated with varnished cambric, then Scotch 130C rubber tape and covered with a minimum of three laps of scotch 33+ electrical tape.
2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

C. 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:

D. Basis-of-Design Product: Subject to compliance with requirements, provide Metraflex Co. or a comparable product by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Pipeline Seal and Insulator, Inc.

E. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   2. Pressure Plates: Stainless steel. Include two (2) for each sealing element.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders smaller than No. 4 AWG; copper for feeders No. 4 AWG and larger. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger. Sizes noted on drawings are for copper.

B. Branch Circuits: Copper. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Use no conductors smaller than No. 12 gauge unless specifically called for or approved by Design Engineer. Size wire for 120-volt branch Circuits for 3% maximum voltage drop. Size feeder circuits for 2 percent maximum voltage drop. Combined voltage drop of feeders and branch circuits shall not exceed 5 percent maximum.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Wire in conduit shall be cross-linked polyethylene type XHHW.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
F. Branch Circuits, below Slabs-on-Grade, and Underground: Type XHHW, cross-linked polyethylene.

G. Class 1 Control Circuits: Type THHN-THWN, in raceway.

H. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Run conductors in conduit continuous between outlets and junction boxes with no splices or taps pulled into conduits.

B. Neatly route, tie and support conductors terminating at switchboards, motor control centers, panelboards, sound equipment, etc., with Thomas & Betts Ty-Rap cable ties and clamps or equivalent by Electrovert or Panduit.

C. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

D. 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.

E. Provide factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90° bends, for pulls in conduits underground or under slabs on grade, and where indicated.

F. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

G. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

H. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

I. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

K. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
   2. Make circuit conductor splices with Buchanan B-Cap nylon insulated connectors or equivalent by Ideal or 3M.
   3. Make fixture and device taps with Scotchlock self-stripping electrical tap connectors.
   4. Terminate solid conductors at equipment terminal strips and other similar terminal point with insulated solderless terminal connectors. Terminate all stranded conductor terminal points with insulated solderless terminal connectors. Provide Thomas & Betts Sta-Kon insulated terminals and connectors or equivalent by API/AMP Blackburn, Buchanan or Scotchlock.
5. Where a total of six or more control and feeder conductors terminate in a multiple device panel or enclosure that has no built-in terminal blocks, provide mounting channel and see-thru covers. Equivalent terminal blocks by General Electric, Square D or Westinghouse.

6. Wrap conductor taps and connections requiring additional insulation with a minimum of three (3) overlapped layers of 3M Scotch vinyl plastic electrical tape No. 88 or equivalent.

L. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

M. No wiring or conduit shall be placed in the concrete slab.

N. All cables 24VDC and under shall be installed in cable tray or conduit. Any conductors operating above 24VDC to be in conduit.

3.4 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels.

B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.

C. Subsequent to wire and cable hookups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows: For conductors #8 and larger, provide a minimum of 10 wraps of color-coded vinyl tape within 6” of conductor termination points or color-coded insulation.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. 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.

D. Extend sleeves installed in floors 2 inches above finished floor level.

E. Size pipe sleeves to provide 0.25-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

F. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

G. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

H. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

I. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

END OF SECTION 260519
SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

B. The requirements as set forth in Division 26 COMMON WORK RESULTS FOR ELECTRICAL Section shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. Extent of electrical grounding and bonding work is indicated by drawings and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.

B. Type of electrical grounding and bonding work specified in this Section includes the following:
   1. Solidly grounded.

C. Applications of electrical grounding and bonding work in this Section includes the following:
   1. Bonding of ALL metal piping
   2. Electrical power systems
   3. Enclosures
   4. Grounding electrodes
   5. Ground Rings
   6. Metal building frames
   7. Raceways
   8. Separately derived systems
   9. Service equipment.
   10. Underground metal water piping

D. Refer to other Division Sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work; not Work of this Section

1.3 SUBMITTALS:

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section.

B. Product Data: Submit manufacturer’s technical product data, including specifications and installation instructions, for each type of grounding system required. Include data substantiating that materials comply with requirements.

C. Submit maintenance data and parts lists for each type of grounding system installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of this specification.
1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer’s Qualifications: Firm with at least 3 years of successful installation experience on projects with electrical grounding work similar to that required for project.

C. Testing Agency’s Qualifications: Firm must be a member company of International Electrical Testing Association (NETA) or a Nationally Recognized Testing Laboratory (NRTL).
   1. Testing Agency’s field supervisor shall have current certification from NETA to supervise and perform ground testing.

D. Codes and Standards:
   1. Electrical Code Compliance: Comply with the adopted electrical code as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.
   2. UL Compliance: Comply with applicable requirements of UL Standards No.’s 467, "Electrical Grounding and Bonding Equipment", and 869 "Electrical Service Equipment", pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Std 486A, "Wire Connectors and soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are UL-listed and labeled for their intended usage.
   3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141, 142 and 1100 pertaining to grounding and bonding of systems, circuits and equipment.
   4. Ground rods to conform to NEMA GRI-2000 Standards for diameter and strength of steel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide grounding and bonding products of one of the following (for each type of product):

1. Adalet-PLM Div; Scott Fetzer Co.
2. Burndy Corporation
3. Cadweld Div; Erico Products Inc.
4. Crouse-Hinds Div; Cooper Industries
5. Eagle Electric Mfg Co.
6. Ideal Industries, Inc.
7. Joslyn Corporation
8. Okonite Company
9. OZ Gedney Div; General Signal Corp.
10. Thomas and Betts Corp.
11. J.A. Weaver Co.
2.2 GROUNDING AND BONDING:

A. Materials and Components:
   1. General: Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is Installer’s option. Where materials or components are not indicated, provide products, which comply with building codes, UL, and IEEE requirements and with established industry standards for those applications indicated.
   2. Conductors: Unless otherwise indicated, provide electrical grounding conductors for grounding system connections that match power supply wiring materials and are sized according to the adopted electrical code.
   3. Bonding Jumper Braid: Copper braided tape, constructed of 30-gage bare copper wires and properly sized for indicated applications.
   5. 5/8" x 10' copper or stainless steel-clad, high-strength steel ground rod with threaded ends for coupling.
   6. Cast bronze with non-ferrous bolts, nuts and lock washers or AMP C-LOK system utilizing a "C" shaped spring member and a wedge, both made of copper alloys that, when applied to grounding conductors or rods, exert a controlled pressure to maintain a permanent connection.

B. Accessories:
   1. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service indicated.
   2. Fusion-Welding: Comply with AWS Code for procedures, appearance, and quality of welds; and for methods used in correcting welding work. Provide fusion welded connections where grounding conductors connect to underground grounding and plate electrodes.

2.3 IDENTIFICATION:

A. Refer to IDENTIFICATION OF ELECTRICAL SYSTEMS for requirements.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.
3.2 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS:

A. General: Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of the Building Codes, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.

C. Fusion-Weld grounding conductors to underground grounding electrodes.

D. Ground electrical service system neutral at service entrance equipment to grounding electrodes.

E. Ground "service entrance" and separately derived system neutral to:
   1. Effectively grounded metallic water pipe
      a. Using a bolted clamp connector, connect grounding conductors to water service entrance piping. Where the meter is installed, provide a bonding jumper to by-pass the meter.
   2. Effectively grounded structural steel member
      a. Install a driven ground rod at the base of each corner structural steel member and at intermediate steel columns on the exterior of the structure not exceeding 50'-0" apart. Each column is then to be bonded to the ground rods.

3. Driven ground rod
   a. Handholes shall be installed at each driven ground rod that will allow for access to the grounding connection to perform annual ground testing. The handhole shall be installed close to wall and flush to finished floors where installed inside and shall be mounted flush to grade where installed outside. Where the ground rod is driven through a concrete floor, the penetration shall be sealed with waterproof, non-shrink grout and the rod shall be protected with a heat-shrunk insulating sleeve or pressure sensitive insulating tape a minimum of 6" below the concrete slab. Handholes shall be provide with a lid that requires a nonproprietary tool to remove. Lids for exterior handholes shall have a drive over rating.
   b. Ground rods shall be installed at least 2" below finished floor or grade level with all connections made without damaging any coating.
   c. A minimum of three ground rods shall be installed no closer than 10'-0" apart and located the same distance apart from other ground rods.

4. Concrete Encased Electrode
   a. Where the concrete is installed with insulation, a vapor barrier or similar barrier separating the concrete from earth, the concrete encased electrode shall not be an acceptable grounding means.

5. Ground Ring
   a. Install a grounding conductor not smaller than 2 AWG, no closer than 24" to the building foundation and at least 30" below final grade. All other grounding electrodes shall be bonded to this ground ring with a minimum of 2 AWG wire.

F. Connect together system neutral, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.
G. Raceway systems shall NOT be used as grounding method. All branch and feeder conduits to have grounding conductor installed with phase and neutral conductors. Size of ground conductor to be in accordance with the adopted electrical code. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug, bus, or bushing.

H. Connect grounding electrode conductors to metal cold water pipe and ALL other types of metal piping within the building using a suitably sized ground clamp. Provide connections to flanged piping to street side of flange. Provide bonding as described in the electrical code including bonding jumper around water meter.

I. Grounding electrode conductors, where not installed as part of a branch circuit or feeder, shall be installed in PVC conduit, to protect the wiring from physical damage.

J. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer’s published torque-tightening values for connectors and bolts. Where manufacturer’s torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

K. Route grounding connections and conductors to ground and protective devices in shortest and straightest paths as possible to minimize transient voltage rises.

L. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

M. Provide frames of motors and other equipment with a code sized stranded copper ground wire inside the flexible conduit connection. Connect this wire inside the junction box at one end and inside the motor terminal box at the other, with cast connector lugs.

N. All receptacles installed shall have a separate grounding contact. Device mounting ears shall make face to face contact with metallic box, which shall be clean and tight.

O. Provide a separate green ground wire from each outlet to a ground lug at the termination of the conduit system. In lieu of ground wire specified above, approved self-grounding receptacles may be used.

P. Electrical channels (i.e. plugmolds, metal wireways) are not acceptable as a means of grounding. Grounding conductors shall be provided in each run and shall extend from the outlets to the termination of the conduit system.

Q. The neutral conductor of all separately derived systems transformers, emergency generators, etc., shall be grounded to the nearest available grounded structure metal member or to the nearest available grounded metal water pipe or as indicated on the drawings. The grounding conductor shall be sized as shown on Drawings or as required by the Electrical Code for an Alternating-Current System.

R. Branch circuits and feeders installed with two ground conductors shall have one Equipment ground conductor (Green) and one isolated ground conductor (Green with yellow strip) installed in same raceway.
3.3 BUILDING TELEPHONE SYSTEM GROUNDING:

A. Provide one #6 copper stranded conductor from building telephone terminal board, to ahead of main water service shut-off valve. Conductor to be terminate at terminal board using one double lug Ilsco or Thomas & Betts terminal kit, bolted to telephone terminal board.

3.4 TELECOMMUNICATIONS/DATA EQUIPMENT GROUNDING:

A. Provide a Telecommunications Main Grounding Busbar (TMGB) in the Entrance Room and Telecommunication Grounding Busbar (TGB) in each Telecommunications Closet as shown on the Drawings and as specified in other Sections of these specifications.

B. Connect the TMGB and all TGB's together with a Telecommunications Bonding Backbone conductor of size shown on Drawings but not smaller than #6 insulated green ground wire.

C. Connect the TMGB to the electrical grounding electrode conductor with any insulated ground wire of size shown on the Drawings but not less than #6 wire.

D. Install grounding bushings on the ends of all telecommunications entrance conduits as well as feeder conduits over 3’ in length and connect them to the nearest grounding busbar with a #6 insulated green ground wire.

E. Connect the equipment ground bus in the 120/208-volt panelboards that serve the same area as the Telecommunications Closet to the respective TGB with a #6 green insulated ground wire in a minimum 1/2” conduit.

F. If a lightning protection system is installed and effectively grounded to the steel structure, any telecommunication ground bar shall not be directly connected to the same steel structure.

3.5 FIELD QUALITY CONTROL:

A. **Upon completion of installation of electrical grounding and bonding systems but before electrical circuits have become energized, engage a qualified testing agency to perform ground testing.**

B. Test ground resistance with ground resistance tester. Test shall be based on Three-Point (Fall of Potential) Method according to IEEE 81, using a 600-volt Biddle megger or equal test equipment. Where tests show resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance. Not more than (3) ground rods will be required.

C. Test shall only occur after two full days without any precipitation.

D. Submit in writing to the Engineer’s office, upon completion of the project, the measured ground resistance of each ground system, indicating the location of the ground rods, the soil condition at the time the measurements were taken, and type of equipment used to measure the ground resistance.
E. Grounding system will be deemed defective if the above tests and inspections do not meet or exceed these requirements and the Contractor will be responsible for correcting and having the testing agency retest.

END OF SECTION 260526
SECTION 260529 – HANGER AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cooper B-Line, Inc.; a division of Cooper Industries.
      b. Thomas & Betts Corporation.
      c. Unistrut; Tyco International, Ltd.
   2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   3. Nonmetallic Coatings: Manufacturer’s standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   4. Painted Coatings: Manufacturer’s standard painted coating applied according to MFMA-4.
   5. Channel Dimensions: Selected for applicable load criteria.

B. 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. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Cooper B-Line, Inc.; a division of Cooper Industries.
      2. Hilti Inc.
      3. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      4. 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.


2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Support vertical and horizontal conduit runs at intervals not greater than 10 feet, within 3 feet of any bend and at every outlet or junction box. Where plastic conduit is used, follow E/M’s recommended hangar spacing.

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 0.25-inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with single-bolt conduit clamps.
E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1.5-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. 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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions 4 inches thick or as otherwise indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete and Miscellaneous Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

D. All conduit raceways and cable trays where exposed in finish space shall be painted to match attached surface or material.

END OF SECTION 260529
SECTION 260533 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 SUBMITTALS
   A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
   B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.3 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.
   C. Comply with applicable requirements of UL 50, UL 514 Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL listed and labeled.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING
   A. Rigid Steel Conduit: Hot dipped galvanized with clear lacquer finish complying with ANSI C80.1.
   B. PVC coated rigid metal conduit complying with ANSI C80.1, UL 6 and NEMA RN-1. Match existing used at for OR Isolation Panel circuits.
   C. EMT: Thin wall with electro-galvanized and clear lacquer finish complying with ANSI C80.3.
   D. 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. Fittings for EMT: Steel, compression type.

2.2 NONMETALLIC CONDUIT AND TUBING
   B. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
2.3 METAL WIREWAYS
A. Manufacturers: Subject to compliance with requirements, provide products by one of
   the following:
   1. Cooper B-Line, Inc.
   2. Hoffman.
   3. Square D; Schneider Electric.
B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 or 3R, as
   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: Flanged-and-gasketed type.
E. Finish: Manufacturer’s standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS
A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed
   cover.
C. Metal Floor Boxes: Cast metal, fully adjustable, rectangular.
D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with
   gasketed cover.
F. 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.
G. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and re-
      moveable front, finished inside and out with manufacturer’s standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.
PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Contractor shall reference “Conduit Application Schedule” on drawings for information relating to conduit types in applications that relate specifically to this project. This schedule is intended to reflect this specification. Where discrepancies are encountered between the schedule and this specification, the Contractor MUST notify the engineer for clarification. If notification by engineer is not requested or provided prior to bid, the most stringent requirement will be enforced.

B. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC.
   2. Concealed Conduit, Aboveground: GRC.
   3. Underground Conduit: RNC, Type EPC-40-PVC. PVC Coated Rigid Steel Conduits below parking lots or traffic areas.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.

C. 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. Corridors used for traffic of mechanized carts, forklifts, and pallet handling units.
      b. Mechanical rooms.
      c. Electrical rooms.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Damp or Wet Locations: Rigid steel conduit.
   6. Raceways for Optical Fiber or Communications Cable: EMT.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

D. EMT Conduit shall be provided for the following application where cable is installed in occupied area without ceiling or cable tray, and in walls to above ceiling:
   1. Data and telephone wiring
   2. Intercom
   3. Fire Alarm
   4. Security System
   5. Cable TV
   6. DDC control wiring

E. Minimum Raceway Size: 0.75-inch trade size.

F. 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. Setscrew fittings shall not be allowed.
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3.2 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 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. Provide insulated throat fittings prior to conductor installation. Failure to do so may result in re-pulling of wiring.

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 within finished walls, ceilings, and floors, unless otherwise indicated. Install exposed conduit parallel or at right angles to building lines. Install all conduit in neat, workman like manner.

H. Make conduit connection to motors and equipment on resilient mounts with liquid-tight flexible conduit.

I. Where conduits cross building expansion joints, provide expansion fittings as required.

J. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.

2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

3. Change from ENT to rigid steel conduit, before rising above the floor.

K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

L. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

M. All below grade non-metallic conduit shall be provided with tracer wire.

N. Raceways for Optical Fiber and Communications Cable: Install as follows:

1. 0.75-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.

2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two (2) 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.

O. 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.

P. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Q. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall.

R. Set metal floor boxes level and flush with finished floor surface.

### 3.3 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."

END OF SECTION 260533
SECTION 260553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Identification for raceways.
   2. Identification of power and control cables.
   3. Identification for conductors.
   5. Warning labels and signs.
   6. Instruction signs.
   7. Equipment identification labels.
   8. Miscellaneous identification products.

1.2 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system service type.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Write-On Tags: Polyester tag, 0.010-inch-thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS
A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
   1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.4 CONDUCTOR IDENTIFICATION MATERIALS
A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
   2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE
A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS
A. Comply with NFPA 70.
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. 0.25-inch grommets in corners for mounting.
   3. Nominal size, 7 by 10 inches.
D. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
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2.7 INSTRUCTION SIGNS  
A. Engraved, laminated acrylic or melamine plastic, minimum 0.625-inch thick for signs up to 20 sq. inches and 0.125-inch 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 0.375-inch.  
C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 0.375-inch. Overlay shall provide a weatherproof and UV-resistant seal for label.  

2.8 EQUIPMENT IDENTIFICATION LABELS  
A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 0.375-inch. Overlay shall provide a weatherproof and UV-resistant seal for label.  
B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 0.375-inch.  
C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.  

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS  
A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).  
B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.  

PART 3 - EXECUTION  
3.1 INSTALLATION  
A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.  
B. Apply identification devices to surfaces that require finish after completing finish work.  
C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.  
D. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.  

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E. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

F. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 30-foot maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

2. Power.

C. Junction Boxes: All junction boxes containing emergency feeder branch circuits shall be painted with colors indicated below. ALL sides of the junction box shall be painted to allow easy identification, including cover.

1. Black – Controls
2. Red – Emergency

D. 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. Control/Instrumentation Wire:
      1) 120VAC control signal: Red
      2) 120VAC line power: Black
      3) 120VAC line neutral: White
      4) Grounds: Green
      5) DC ungrounded Control Circuits: Blue
      6) DC grounded Control Circuits: White with Blue stripe
      7) Analog Pair: Black/White or Black/Red
      8) Instrument signal Cable Jacket: Black or Gray
      9) RTD V+ (device): Black
      10) RTD V- (device): White
11) RTD compensation (device): Red
12) Externally powered: Orange
13) Intrinsically Safe: Light Blue

e. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches 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.

E. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches.
      b. Controls with external control power connections.

I. 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.

J. 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:
      TYPE 1: Laminated phenolic plastic with black Gothic-condensed lettering by Sea- ton or Wilco.

      TYPE 2: Self-sticking 0.5-inch wide flexible nylon tape with high gloss surface and typed smearproof, chemical/solvent resistant lettering by Brady or Dymo.
TYPE 3: Self-sticking polyester sign with wording and size conforming to ANSI Standard Z35.1 - 1964 and OSHA 19.0.144iii(2) Specifications, by Brady or as approved.

TYPE 4: Self-sticking flexible vinyl with oil resistant adhesive for -20 degrees to 300 degrees F. temperatures by Brady or as approved.

a. Provide switchboards with Type 1 signs 2.5 inches x 12 inches indicating switchboards designation and electrical characteristics as noted on drawings. Provide switchboards sections operating at different voltages with Type 1 sign 2 inches by 8 inches indicating electrical characteristics of section. Provide each switchboard device with Type 1 sign 1.25 inches by 5 inches indicating load served.

b. Provide distribution panelboards with Type 1 signs 2 inches by 8 inches indicating panel designation and electrical characteristics. Provide branch devices with Type 1 sign 1 inch by 4 inches indicating load served.

c. Provide lighting and power panelboards with Type 1 sign 1.25 inches by 6 inches indicating panel designation, electrical characteristics, and source of power. Source of power indication shall indicate source panel designation and switch or breaker number. Mount inside of panel door on circuit breaker trim flange just below breakers.

d. Provide disconnect switches, time switches, lighting contactors, motor starters and controllers with Type 1 sign 1.25 inches by 6 inches indicating equipment served, electrical characteristics, and source of power.

e. Provide feeders and branch circuit home runs with Type 4 wire marker indicating circuit number and power source. Provide feeders phase identification letter at each terminal point in addition to its circuit number.

f. Provide Type 2 tape at feeder terminal lugs to switchboards and panelboards. Tape shall indicate conduit size, conductor type and AWG size. Tape shall be located to be easily read with conductors installed.

K. Panelboard Labeling:

1. Contractor shall provide new circuit directories at all panelboards in which a load alteration has occurred. Labels shall be typed, posted to the inside of the panelboard door and indicate all new and existing loads. Existing loads that have been removed shall be labeled as “spare”. Existing loads that have been altered (reused or added) shall be indicate the (new) load served on the directory.

END OF SECTION 260553
SECTION 260913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:

1. Monitoring and control of power distribution equipment.
2. Raceways and boxes.
3. Wires and cables.
4. Identification.

B. Related Requirements:

1. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For power monitoring and control equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.

a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:

1) Location of the meters and gateways, and routing of the connecting wiring.
2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
3) Provide indication of equipment or devices to be provided by Trane and items to be provided/installed by the Electrical or Mechanical Contractor.
4) Electrical energy metering shall be provided through circuit breaker electronic trip units as defined on plans.

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. Include diagrams for power, signal, and control wiring.
5. Surge Suppressors: Data for each device used and where applied.
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1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Other Informational Submittals:

1. Manufacturer’s system installation and setup guides, with data forms to plan and record options and setup decisions.
   a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
   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. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
   e. Owner training materials.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.6 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.


B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:

1. Electrical meters that monitor and connect to the data transmission network.
2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.

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. UL Compliance: Listed and labeled as complying with UL 61010-1.

D. Contractor shall provide energy monitoring meters within distribution circuit breakers readily available to integrate into building BAS.

E. Contractor shall verify all equipment to be provided and/or provided and installed by Trane. Obtain a bid number from Trane for their work and include all additional cost for equipment and installation provisions by Contractor. Include all cost in bid.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.

2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.

1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor.

2. Modbus communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

2.3 CIRCUIT METERS AND MONITORS

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

1. Eaton.
2. General Electric Company.
3. Schneider Electric USA, Inc.
B. Description: Integraly mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.

C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

D. Accuracy:
1. Comply with ANSI C12.20, Class 0.5.
2. For Voltage and Current: 0.5 percent of reading.
3. For Active Power: 0.2 percent.
4. For Active and Reactive Energy: ANSI 12.20, Class 0.2.
5. For Frequency: 0.01 Hz in the range of 45 to 65 Hz.
6. For Power Factor: 0.2 percent from 0.5 leading to 0.5 lagging.

E. Data Link:
1. Modbus TCP:
   a. 10/100BaseTX UTP. RJ-45 connector, 100-m link.

F. Sampling Rate:
1. Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on all voltage and current channels of the meter.

G. Meters shall measure, record with time stamp, calculate, and on request display the following:
1. Measurements: Instantaneous, in real time, rms to the 31st harmonic:
   b. Current: Each phase, three-phase average, and neutral.
   c. Active Power (kW): Each phase and three-phase total.
   d. Reactive Power (kVAR): Each phase and three-phase total.
   e. Apparent Power (kVA): Each phase and three-phase total.
   f. Displacement Power Factor: Each phase and three-phase total.
   g. Distortion Power Factor: Each phase and three-phase total.
   h. Frequency.
2. THD from measurements simultaneously from the same cycle, through 31st harmonic:
   b. Current: Each phase, three-phase average, and neutral.
3. Energy: Accumulated, indicate in-flow or out-flow, net and absolute values. Store the values in instrument’s nonvolatile memory. Provide for storing accumulated energy at user-defined intervals, up to three intervals per day.
   a. Active kWh.
   b. Reactive kVARh.
4. Demand: Three-phase totals, present, predicted, peak.
   a. Average current.
   b. Active power (kW).
   c. Reactive power (kVAR).
   d. Apparent power (kVA).
5. Average, Minimum and Maximum Values:
   a. Record, date and time stamp, and save the minimum and maximum values of all rms metered values since the last reset.

H. Power Demand, User Selectable:
1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
   a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
   b. Fixed block that calculates demand at end of the interval.
   c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a Synchronization Signal:
   a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
   b. Synchronize demand with receipt of a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
   c. Provide for synchronization to the clock in the instrument.
4. KY Pulse: Generate a standard KY pulses for a user-defined increment of metered active energy as follows:
   a. User-defined pulse output, associated with kWh.
   b. Alarm pulse output, which turns on the pulsing at user-defined point.
5. Digital Inputs: As follows:
   a. One input connection rated 24- to 125-V ac or -V dc, +/- 10 percent, less than 5-mA burden, 1350-V rms isolation.
   b. Six input connections rated 19- to 30-V dc, 5 mA maximum at 24-V dc. Provide an onboard 24-V dc power supply.
   c. Two input connections rated 20- to 150-V dc or -V ac, 2 mA maximum.
6. Analog inputs, no fewer than two, adjustable from 0- to 5-V dc or 4 to 20 mA.
7. Outputs to operate field-installed relays, no fewer than two, providing 6- to 240-V ac or 6- to 30-V dc, 2 A rms. 5 A maximum for 10 seconds per hour.
8. Analog outputs, no fewer than two, 4- to 20-mA dc into 600 ohms maximum.
2.4 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.


1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Distribution Equipment Monitoring:

1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
2. Display Data:
   a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).
   b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
   c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
   d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
   e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
   f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).

2.5 SYSTEM OPERATOR INTERFACES

A. Operator means of system access shall be through the following:

1. Desktop operator workstation with hardwired connection through LAN port.
2. Remote connection using outside of system PC, tablet, or phone using an internet portal.

2.6 DESKTOP OPERATOR WORKSTATION

A. Owner shall be responsible for provision of PC compatible with energy monitoring software.
2.7 RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.

PART 3 - EXECUTION

3.1 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.


C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:
   1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
   2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

E. Raceways Installation:
   1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
   2. Comply with Section 270528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.

F. Identification Installation:
   1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
   2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for UTP and low-voltage control cable.

3.2 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.
B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test UTP 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 its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "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.


   a. Test Analog Signals:

      1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

      2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.

      3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

   b. Test Digital Signals:

      1) Check digital signals using a jumper wire.

      2) Check digital signals using an ohmmeter to test for contact making or breaking.

C. Wiring and cabling will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.
3.4 FINAL REVIEW

A. Submit written request to Architect when the power monitoring and control system is ready for final review. Written request shall state the following:

1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
4. The system is complete and ready for final review.

B. Review by Architect will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.

B. Extent of Training:

1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:
   a. Provide no fewer than one day of training total.
   b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
   c. Total days of training shall be broken into training classes to meet Owner schedule

C. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.
END OF SECTION 260913
SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Time switches.
2. Outdoor and indoor photoelectric switches.
3. Indoor occupancy sensors.
4. Lighting contactors.
5. Emergency shunt relays.

B. Related Sections include the following:

1. Division 26 Sections "Modular Dimming Controls" for architectural dimming system equipment.
2. Division 26 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.
3. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

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

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
1.5 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.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
5. Lightolier Controls; a Genlyte Company.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
8. Square D; Schneider Electric.
9. TORK.
10. Touch-Plate, Inc.
11. Watt Stopper (The).

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: SPST.
2. Contact Rating: 30-A inductive or resistive, 240-V ac.
3. Retain one of first eight subparagraphs below.
4. Program: 8 on-off set points on a 24-hour schedule.
5. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
6. Programs: 4 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
7. Programs: 4 channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.
8. Programs: 2 channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
9. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
10. Astronomic Time: All channels.
11. Battery Backup: For schedules and time clock.
2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

C. Description: Solid state, with SPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.

2.3 INDOOR PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

3. Eaton Electrical Inc; Cutler-Hammer Products.
5. Intermatic, Inc.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
8. Novitas, Inc.
10. Square D; Schneider Electric.
11. TORK.
12. Touch-Plate, Inc.
13. Watt Stopper (The).

B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
2. Relay unit in subparagraph below is suitable for controlling a single lighting circuit, provided the circuit load does not exceed the listed aggregate load.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Retain second option in first subparagraph below for lighting control of interior spaces with large window areas, including atriums and corridors; otherwise, retain first option.
5. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
6. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
7. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Hubbell Lighting.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Novitas, Inc.
5. RAB Lighting, Inc.
6. Sensor Switch, Inc.
7. TORK.
8. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
b. **Relay**: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.

c. **Time-Delay and Sensitivity Adjustments**: Recessed and concealed behind hinged door.

5. **Indicator**: LED, to show when motion is being detected during testing and normal operation of the sensor.

6. **Bypass Switch**: Override the on function in case of sensor failure.

7. **Automatic Light-Level Sensor**: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

C. **Dual-Technology Type**: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. **Sensitivity Adjustment**: Separate for each sensing technology.

2. **Detector Sensitivity**: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. **Detection Coverage (Standard Room)**: Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

### 2.5 LIGHTING CONTACTORS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
4. GE Industrial Systems; Total Lighting Control.
5. Grasslin Controls Corporation; a GE Industrial Systems Company.
6. Hubbell Lighting.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
9. Square D; Schneider Electric.
10. TORK.
11. Touch-Plate, Inc.
12. Watt Stopper (The).

B. **Description**: Electrically operated and mechanically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.

1. **Current Rating for Switching**: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. **Fault Current Withstand Rating**: Equal to or exceeding the available fault current at the point of installation.

3. **Enclosure**: Comply with NEMA 250.

4. **Provide with control and pilot devices as indicated on Drawings**, matching the NEMA type specified for the enclosure.
2.6 EMERGENCY SHUNT RELAY

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. Lighting Control and Design, Inc.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."

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

END OF SECTION 260923
SECTION 260926 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1. SUMMARY

A. The Contractor shall coordinate all work in this section with all of trades covered in other sections of the specification to provide a complete and operable system. The extent of the lighting control system work is indicated by the drawings and by the requirements of this section. It is defined to include, but not by way of limitation.

B. Where indicated on drawings or reasonably inferred, provide a distributed type lighting control system.

C. The lighting control system shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control. The system shall be capable of turning lighting loads on/off as well as dimming (if lighting load is capable of being dimmed). All system devices shall be networked together enabling digital communication and shall be individually addressable. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost. The system architecture can facilitate remote operation via a computer connection. The system shall not require any centrally hardwired switching equipment.

D. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time-based operation.

E. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible to minimize overall device count of system.

F. System must interface directly with intelligent LED luminaires such that only CAT-5 cabling is required to interconnect luminaires with control components such as sensors and switches (see section

1. System installation includes the following:
   a. Wiring of main and branch circuit conductors
   b. Installation of external control devices and wiring to the panelboard controller.
   c. Installation of communications conductors and associated hardware

1.2. QUALITY ASSURANCE

A. Manufacturers: Firms engaged in the manufacture of lighting control equipment and ancillary equipment, of the types indicated, whose products have been in satisfactory use in similar service for not less than five years.


C. Component Testing: All electronic component board assemblies are to be factory tested and burned in prior to installation.
D. System Support: Factory fax/telephone/email support shall be available free of charge during normal business hours.

1.3. REFERENCES

A. NEMA Compliance: Applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

B. NEC Compliance: Applicable portions of the NEC including Articles 110-10.

C. UL Compliance: Applicable UL standards for panelboards, circuit breakers and energy management equipment.

D. FCC Emissions: Compliance with FCC emissions Standards specified in Part 15, Subpart J for Class A applications

E. California Title 24: All lighting control equipment shall be certified by the California Energy Commission.

F. Seismic compliance: NFPA 5000, ASCE7, ICC ES AC156

1.4. WARRANTY

A. Manufacturer shall warrant specified equipment to be free from defects in materials and workmanship for at least one year from the date of installation or eighteen months from date of purchase.

1.5. MANUFACTURES

A. Acceptable manufacturer: Wattstopper DLM, N-Light, Lutron, or other approved equal.

B. Substitutions

1. All substitutions (clearly identified as such) must be submitted in writing for approval by the design professional at least 7 working days prior to bid date. Substitutions must be available to all bidders.

2. Proposed substitutions must include detailed summary of specification review noting compliance online basis.

3. Contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and structural changes

4. Complete shop drawings with deviations are required for review prior to installation and rough-in.

1.6. SUBMITTALS

A. Product Data Sheets: Submit manufacturer’s data sheet for the lighting control system and specified components

B. Panel Drawings: Submit manufacturer’s dimensional drawings and circuit breaker placement locations for each panelboard.

C. One Line Diagram: Submit a one-line diagram of the system configuration proposed if it differs from that illustrated in the riser diagram included in these specifications.
D. Typical Wiring Diagrams: Submit typical connection diagrams for all components including, but not limited to, panelboards, low voltage switches, occupancy sensors, light level controllers, communications devices, and personal computers.

E. Substitutions: If a system from another manufacturer is submitted for approval, the following submittals are required: Short circuit study demonstrating NEC110-10 compliance for all remotely operated switching devices. Elevation drawing showing placement of equipment in equipment rooms.

PART 2 - MATERIALS AND COMPONENTS

2.1 NETWORK LIGHTING CONTROLS SYSTEM

A. Digital Occupancy Control System

1. Basis of design product: Wattstopper Digital Lighting Management (DLM) or subject to compliance and prior approval with specified requirements of this section, one of the following:
   a. Watt Stopper; Legrand Group (Basis of Design)
   b. nLight: Acuity Brands.

2. Digital Ceiling mounted occupancy sensor system.
   a. Ceiling mounted passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company’s system which accommodates the square-foot coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors and accessories which suit the lighting and electrical system parameters.
   b. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
      1) Digital calibration and pushbutton programming for the following variables:
         a) Sensitivity – 0-100% in 10% increments
         b) Time delay – 1-30 minutes in 1-minute increments
         c) Test mode – Five second time delay
         d) Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
         e) Walk-through mode
         f) Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photo sensors are included in the DLM local network.
      2) One or two RJ-45 port(s) for connection to DLM local network.
      3) Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
      4) Device Status LEDs including:
         a) PIR Detection
         b) Ultrasonic detection
         c) Configuration mode
         d) Load binding
5) Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
6) Manual override of controlled loads.

c. Units shall not have any dip switches or potentiometers for field settings.
d. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.
e. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC

B. Digital Wall Switches

1. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration; available in white, light almond, ivory, grey and black; compatible with wall plates with decorator opening. Wall switches shall include the following features:
   a. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
   b. 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.
   c. Red configuration LED on each switch that blinks to indicate data transmission.
   d. Blue Load/Scene Status LED on each switch button with the following characteristics:
      1) Bi-level LED
      2) Dim locator level indicates power to switch
      3) Bright status level indicates that load or scene is active
   e. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.

2. Two RJ-45 ports for connection to DLM local network.
3. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching.
4. The following switch attributes may be changed or selected using a wireless configuration tool:
   a. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
   b. Individual button function may be configured to Toggle, On only or Off only.
   c. Individual scenes may be locked to prevent unauthorized change.
   d. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
   e. Ramp rate may be adjusted for each dimmer switch.
   f. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.


C. Room Controllers

1. Room Controllers automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers
will be simple to install and will not have, dip switches, potentiometers or require special configuration. The control units will include the following features:

a. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.

b. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.

c. Device Status LEDs to indicate:
   1) Data transmission
   2) Device has power
   3) Status for each load
   4) Configuration status

d. Quick installation features including:
   1) Standard junction box mounting
   2) Quick low voltage connections using standard RJ-45 patch cable
      a) Plenum rated
      b) Manual override and LED indication for each load
      c) Dual voltage (120/277 VAC, 60 Hz)
      d) Zero cross circuitry for each load.

2. On/Off Room Controllers shall include:
   a. One or two relay configuration
   b. Efficient 150 mA switching power supply
   c. Three RJ-45 DLM local network ports
   d. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
   e. One relay configuration only
      1) Automatic-ON/OFF configuration
   f. WattStopper product numbers: LMRC-101, LMRC-102, LMPL-101

3. On/Off/Dimming enhanced Room Controllers shall include:
   a. Real time current monitoring
   b. One, two or three relay configuration
   c. Efficient 250 mA switching power supply
   d. Four RJ-45 DLM local network ports.
   e. One 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
   f. Optional Network Bridge for BACnet MS/TP communications (LMRC-3xx).
   g. The following dimming attributes may be changed or selected using a wireless configuration tool:
      1) Establish preset level for each load from 0-100%
      2) Set high and low trim for each load
      3) Set lamp burn in time for each load up to 100 hours
   h. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
      1) One relay configuration only
      2) Automatic-ON/OFF configuration
i. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMPL-201, LMRC-311, LRMC-312, LMRC-313.

j. Isolated Relay Interface
   1) With each room controller, provide an isolated relay interface (as required) Wattstopper LMRL-100 for local control of HVAC equipment per mechanical details.
   2) The LMRL-100 contains a single-pole, double throw isolated relay and normally open (N/O), normally closed (N/C) and common outputs.

D. Room Network (DLM Local Network)
   1. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building. Digital room devices connect to the network using CAT 5e cables with RJ-45 connectors which provide both data and power to room devices. Features of the DLM local network include:
      a. Plug n’ Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
      b. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
      c. Push n’ Learn configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
      d. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

E. Configurations Tools
   1. A configuration tool facilitates optional customization of DLM local networks and is used to set up open loop daylighting sensors. A wireless configuration tool features infrared communication, while PC software connects to each local network via a USB interface.
   2. Features and functionality of the wireless configuration tool shall include:
      a. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
      b. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
      c. Read, modify and send parameters for occupancy sensors, room controllers and buttons on digital wall switches.
      d. Save up to nine occupancy sensor setting profiles, and apply profiles to selected sensors.
      e. Temporarily adjust light level of any load(s) on the local network and incorporate those levels in scene setting.
   3. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100
F. Network Bridge

1. The network bridge connects a DLM local network to a BACnet-compliant network for communication between rooms, panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication.

   a. The network bridge may be incorporated directly into the room controller hardware (LMRC-3xx Room Controllers) or be provided as a separate module connected on the local network through an available RJ-45 port.

   b. Provide Plug n’ Go operation to automatically discover all room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.

   c. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. Standard BACnet objects shall be provided as follows:

      1) Read/write the normal or after-hours schedule state for the room
      2) Read the detection state of the occupancy sensor
      3) Read/write the On/Off state of loads
      4) Read/write the dimmed light level of loads
      5) Read the button states of switches
      6) Read total current in amps, and total power in watts through the room controller
      7) Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
      8) Activate a preset scene for the room
      9) Read/write daylight sensor fade time and say and night setpoints
     10) Read the current light level, in footcandles, from interior and exterior photosensors and photocells
     11) Set daylight sensor operating mode
     12) Read/write wall switch lock status

d. WattStopper product numbers: LMBC-300

G. Segment Manager

1. The Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser. Each segment manager shall have support for one, two or three segment networks as required and allow for control of a maximum of 127 local networks (rooms) and/or lighting control panels per segment network.

2. Operational features of the Segment Manager shall include the following:

   a. Connection to PC or LAN via standard Ethernet TCP/IP.
   b. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser.
   c. Log in security capable of restricting some users to view-only or other limited operations.
d. Automatic discovery of all DLM devices on the segment network(s). Commissioning beyond activation of the discovery function shall not be required.

e. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.

f. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation.

g. Ability to set up schedules for rooms and panels. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation.

h. Ability to group rooms and loads for common control by schedules, switches or network commands.

i. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.

3. Provide seamless integration with the BAS via BACnet IP
   a. WattStopper Product Numbers: LMSM-3E, LMSM-6E.

4. LMCP Digital Lighting Management Relay Panel
   a. Provide up to 8, 24 or 48 (number of relays as noted on the drawings) mechanically latching relays. Relays include a manual override and a single push on connector for easy installation of removal from the panel. Panel accepts program changes from handheld configuration tool for date and time, location, holidays, event scheduling, button binding and group programming. Provides BACnet MS/TP compliant digital networked communication between other lighting controls and or building automation system (BAS).

   b. Enclosure shall be NEMA 1 sized to accept an interior with 1-24 relays and 6 four pole contactors. (or 1-48 relays and 6 four pole contactors). Number of relays as noted on the drawings.

   c. Cover shall be configured for surface wall mounting. Panel shall have a hinged and lockable door with restricted access to line voltage section of the panel.

   d. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:

   e. Removable, plug-in terminal blocks with connections for all low voltage terminations.

   f. Individual terminal block, override pushbutton, and LED status light for each relay.

   g. Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.

   h. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or
maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.

i. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.

j. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.

k. Group and pattern control of relays shall be provided through a simple keypad interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.

l. Relay group status shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.

m. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:

1) Electrical:
   a) 20amp tungsten at 120V
   b) 1.5 HP motor at 120V
   c) Relays shall be specifically UL 20 listed for control of plug-loads

2) Mechanical:
   a) Replaceable, %2” KO mounting with removable Class 2 wire harness.
   b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
   c) Dual line and load terminals each support two #14 - #12 solid or stranded conductors.
   d) Tested to 300,000 mechanical on/off cycles.

n. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.

o. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

p. Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic by pass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article 700.

q. Integral system clock shall provide scheduling capabilities for panel.

r. Each panel shall include digital clock capability able to issue system wide automation commands to up to (11) eleven other panels for a total of (12) twelve networked lighting control panels. The clock shall provide capability
for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.

s. The clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.

t. The clock module shall provide astronomical capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for the clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.

u. The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:

1) Scheduled ON / OFF
2) Manual ON / Scheduled OFF
3) Astro ON / OFF (or Photo ON / OFF)
4) Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)

v. The user interface shall be a portable IR handheld remote control capable of programming any panel in the system (LMCT-100)

w. The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.

x. Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost. Lighting control panels that are not capable of executing events independently of the global network shall not be acceptable.

5. The lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.

6. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet protocol.

a. The panel shall have provision for an individual BACnet device ID and shall support the full 222 range (0 – 4,193,304). The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.

b. The panel shall support MS/TP MAC addresses in the range of 0 - 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.

c. Lighting control relays shall be controllable as binary output objects in the instance range of 1 - 64. The state of each relay shall be readable and writable by the BAS via the object present value property.

d. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 - 64.

e. The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 - 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours’ mode. Commanding 0 or NULL shall put the relays into the after-hours mode.
f. Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:

g. Binary output objects in the instance range of 1 - 64 (one per relay) for on/off control of relays.

h. Binary value objects in the instance range of 1 - 99 (one per channel) for normal hours/after hours schedule control.

i. Binary input objects in the instance range of 1 - 64 (one per relay) for reading true on/off state of the relays.

j. Analog value objects in the instance range of 101 - 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.

k. The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.

l. The BO and BV 1 - 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object described in addendum aa. (http://www.bacnet.org/Addenda/Add-135-2010aa.pdf)

m. Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.

n. Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.

4. Emergency Lighting Control Unit (ELCU)

a. Allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building.

b. ELCU shall be installed at room controllers in conjunction with a central inverter such that the emergency lighting is capable of being switched/controlled as a normal fixture but activates as an emergency fixture upon loss of power to the normal circuit serving the room controller.

H. Switchbox-Mounted Occupancy Sensors

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

   a. Bryant Electric; a Hubbell company.

   b. Cooper Industries, Inc.

   c. Hubbell Building Automation, Inc.

   d. Leviton Mfg. Company Inc.

   e. Lithonia Lighting; Acuity Lighting Group, Inc.

   f. Lutron Electronics Co., Inc.

   g. Sensor Switch, Inc.

   h. Square D; a brand of Schneider Electric.

   i. Watt Stopper.
   a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   b. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
   c. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

3. Wall-Switch Sensor Tag 'MS':
   a. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
   b. Sensing Technology: Dual technology - PIR and ultrasonic.
   c. Switch Type: SP.
   d. Voltage: Dual voltage, 120 and 277 V; dual-technology type.
   e. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
   f. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

I. Lighting Contactors

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   b. ASCO Power Technologies, LP; a division of Emerson Electric Co.
   c. Eaton Corporation.
   d. Intermatic
   e. Square D; a brand of Schneider Electric.
   f. TORK
   g. Watt Stopper (The)

2. Description: Electrically operated and electrically held, combination-type lighting contactors, complying with NEMA ICS 2 and UL 508.
   a. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
   b. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
   c. Enclosure: Comply with NEMA 250.

Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.2 NETWORKS

A. Ethernet Network:

1. Installing contractor shall coordinate work with the network administrator to assure that proper connection points are available. The installing contractor shall also secure static IP address for each individual master controller and power monitoring web server.
2. Network shall support Ethernet 10Base-T communications.
3. Communications wiring to master panels shall be Category 5 cable having 8 position 8 contact (8P8C) modular plugs terminated using the T568A or T568B pin/pair assignments as defined in TIA/EIA-568-B.

B. Communications wiring to master panels shall use Category 5 cabling. Installing contractor shall coordinate work with the network administrator to assure that proper connection points are available. The installing contractor shall also secure one static IP address for each master controller.

PART 3 – EXECUTION

3.1. CUSTOMIZATION

A. Manufacturer shall provide any custom hardware or communication devices necessary to make the system perform as specified above.

B. Manufacturer shall provide PC user interface custom screens. Rough layouts of the screens will be provided to the manufacturer no less than 30 days before scheduled system start-up.

3.2. CONTRACTOR INSTALLATION

A. Install equipment in accordance with manufacturers installation bulletins.

B. Provide complete installation in accordance with contract documents.

C. Define each circuit breaker, dimmer, relay load type and assign to required zone, input and/or schedule.

D. Provide-as built drawings indicating sensor placements on drawings.

E. Provide one-line drawing indicating location and addresses of all networked hardware including panels, distributed relays and dimmers, keypads, and sensors

F. Sensor Installation

1. 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.

2. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer’s written instructions.

3. When using wire for connections other than the DLM local network (Cat 5e with RJ-45 connectors), provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

4. Install the work of this Section in accordance with manufacturer’s printed instructions unless otherwise indicated.

G. Perform the following tests and inspections with the assistance of a factory-authorized service representative. Owner shall be provided the opportunity to witness all testing.

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.

H. Re-commissioning – After 30 days from occupancy re-calibrate all sensor time delays and sensitivities to meet the Owner’s Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.

I. Lighting control devices will be considered defective if they do not pass tests and inspections.

J. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
   1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
   2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
   3. Load Parameters (e.g. blink warning, etc.)

K. Prepare test and inspection reports.

L. Wiring Installation
   2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
   3. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
   4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

M. Identification
   1. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
      a. Identify controlled circuits in lighting contactors.
      b. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
   2. Label time switches and contactors with a unique designation.

3.3. SYSTEM PROGRAMMING

A. Contractor is responsible for furnishing fully functional system including all necessary programming, calibration, and operational interfaces to other devices.

B. Contractor shall meet with owner’s representative to identify desired operation of the control system. At minimum, the lighting control system shall meet the functional requirements of the applicable energy building code for the location of the property.

C. Contractor shall fully document the control operation of the system including zone definitions, time schedules, input assignments, scenes, dimmer setpoints, occupancy sensor delays, light level settings, and any other special requirements including information that is to
be shared with other building systems. Full documentation shall be made available to the owner’s rep and the manufacturer no less than 14 days before planned start up.

3.4. START-UP

A. Installing contractor shall provide factory-certified field service for site inspection to assure proper system installation and operation.

1. Factory service technicians shall:
   a. Have certification demonstrating competency with associated controls systems
   b. Be certified by the manufacturer on the system installation and programming.

2. Upon visit, the technician will be responsible for performing the following:
   a. Verify power feeds and load circuits are properly labeled according to drawings
   b. Verify connection and location of all external controls
   c. Verify addressing of all network components in relation to drawings
   d. Verify equipment is properly operating in accordance with approved drawings and sequence of operations
   e. Verify operation of supplied interfaces with other equipment
   f. Verify sensors are properly calibrated
   g. Obtain sign-off on system functions

3.5. FACTORY COMMISSIONING

A. Upon completion of the installation, the system shall be commissioned by the manufacturer’s factory authorized representative who will verify a complete fully functional system.

B. The electrical contractor shall provide both the manufacturer and the electrical engineer ten working days written notice of the system startup and adjustment date.

END OF SECTION 260926
SECTION 260936 - MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

2. Integrated, multipreset modular dimming controls.

1.3 DEFINITIONS

A. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

B. 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.

C. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

D. SCR: Silicon-controlled rectifier.

E. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.4 SUBMITTALS

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

1. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
2. Device plates and plate color and material.

B. Samples for Initial Selection: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.

C. Samples for Verification: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.
1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:

1. Division 26 Section "Lighting Control Devices."

PART 2 - PRODUCTS

2.1 GENERAL DIMMING DEVICE REQUIREMENTS

A. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.

B. 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.

2.2 MANUAL MODULAR MULTISCENE DIMMING CONTROLS

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:

C. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or a comparable product by one of the following:

2. Lightolier Controls; a division of Lightolier; a Genlyte Group.
3. Lutron Electronics, Inc.
4. Douglas Controls

D. Description: Factory-fabricated equipment providing manual modular dimming control consisting of a wall-box-mounted, master-scene controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in one-,
or three-gang wall box under a single wall plate. Each zone station shall be adjustable to indicated number of scenes, which shall be recorded on the zone controller.

E. Operation: Automatically change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.

F. Each manual modular multiscene dimming controller shall include a master control and remote controls.

G. Each zone shall be configurable to control the following:
   1. LED (light emitting diode) with dimming driver

H. Memory: Retain preset scenes through power failures for at least seven days.

I. Device Plates: Style, material, and color shall comply with Division 26 Section "Wiring Devices."

J. Master-Scene Controller: Suitable for mounting in a single flush wall box.
   1. Switches: Master off, group dim, group bright, and selectors for each scene.
   2. LED indicator lights, one associated with each scene switch, and one for the master off switch.

K. LED Zone Dimmer: Suitable for operating lighting fixtures and ballasts specified in Division 26 Section "Interior Lighting," and arranged to dim number of scenes indicated for the master-scene controller. Scene selection is at the master-scene controller for setting light levels of each zone associated with scene.
   1. Switch: Slider style for setting the light level for each scene.
   2. LED indicator lights, one associated with each scene.
   3. Electrical Rating: 2000 VA, 120 V.

2.3 INTEGRATED, MULTIPRESET MODULAR DIMMING CONTROLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or a comparable product by one of the following:
   1. Douglas Lighting Controls.
   3. Lightolier Controls; a division of Lightolier; a Genlyte Group.
   4. Lithonia Lighting.
   5. Lutron Electronics, Inc.
   6. Marlin Controls.

B. Indicate number of wall-box, remote-control stations.

C. Description: Factory-fabricated, microprocessor-based, solid-state controls providing manual dimming control consisting of a master station and multiple wall-box, remote-control stations.
D. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.

E. Each zone shall be configurable to control the following:
   1. LED (light emitting diode) with dimming driver.

F. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.

G. Master Station:
   1. Contains control panel and multiple control and dimmer modules.
   2. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
      a. Master zone raises and lowers lighting level.
      b. Adjustable fade rate for each scene from 1 to 60 seconds.
   3. Rear-illuminated, scene-select buttons.
   4. Lighting-level setting and fade-rate setting shall be graphically shown using LEDs or backlit bar-graph indicator.

H. Remote-Control Stations:
   1. Numbered push buttons to select scenes.
   2. Off switch to turn master station off.
   3. On switch turns all scenes of master station to full bright.

I. Infrared Remote-Control Station: Same functions as for standard remote-control station, except that functions are input by a hand-held infrared transmitter.

J. Dimmers: Modular, plug-in type, with circuit breaker to protect the dimmer and branch circuit.
   1. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
   2. Dimming Curve: Modified "square law" as specified in IESNA's "IESNA Lighting Handbook"; control voltage is 0- to 10-V dc.
   3. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
   4. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.
   5. Short-Circuit Rating: 14 kA for 277 V.

2.4 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch.

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.

3.2 IDENTIFICATION

A. Comply with requirements in Division 26 Section "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.

3.3 FIELD QUALITY CONTROL

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

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. 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 modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

D. Remove and replace malfunctioning modular dimming control components and retest as specified above.

E. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

F. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls.

B. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."

END OF SECTION 260936
SECTION 262200 – LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency’s Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer’s written instructions.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton.
2. Square D
3. GE
4. Siemens

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

1. Coil Material: Copper.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 61 gray.

E. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

F. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

H. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.
I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. 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.
   3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

K. 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.

L. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

M. Wall Brackets: Manufacturer's standard brackets.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

B. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
E. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

F. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer’s written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. 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.

G. Secure transformer to concrete base according to manufacturer’s written instructions.

H. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

I. Remove shipping bolts, blocking, and wedges.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. 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.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.4 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 5 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.


END OF SECTION 262200
SECTION 262213 – LOW VOLTAGE DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 WORK INCLUDES
A. Metal enclosed low voltage (600-volt) power circuit breaker distribution panelboards.
B. This section includes requirements for distribution panelboard, including main breaker(s), and distribution overcurrent protective devices.
C. Breakers within existing I-line type of panelboards and motor control centers.

1.2 SUBMITTALS
A. Submit in accordance with Division 1, Section 01300.
B. Product Data: Submit manufacturer’s technical product data covering the entire assembly, circuit breakers, trip units, control and metering components. Data shall also indicate voltage, phase, frequency, current rating and short circuit rating of the switchgear. Include assembly storing, handling, and installation instructions.
C. Operation & Maintenance Data: Submit operation & maintenance data including parts lists, furnished assembly, specialties and accessories. Include this data, product data, and shop drawings in "Operation & Maintenance" manual, in accordance with requirements of the General Conditions of this Specification.
D. Shop Drawings: Submit the following types of manufacturer's drawings:
   1. Outline assembly drawings indicating dimensions, and weight loadings, bus work layouts and mountings, device layouts, assembly structural details, mountings and supports;
   2. One-line diagram of switchgear indicating ratings, of all devices, device types, bussing and lug capacities;
   3. External connections and internal wiring diagrams;
   4. Control schematic diagrams;
   5. Scale front, rear, and end views of equipment with material list device catalog sheets, and nameplate schedule;
   6. Sectional view of each section of panelboard or transfer switch showing construction, size and location of bussing and cabling furnished;
   7. AIC/Fault current ratings of all equipment.
   8. Schematic and Wiring Diagrams (including point by point) for circuit breaker controls, alarms, terminal blocks and all connections within the switchboard;
   9. Complete detailed instructions on operation;
   10. Coordination curves for each type and size breaker and fuse used;
   11. Detail factory installed wiring and connections to be field provided;
   12. Metering provisions;
E. Upon completion of project provide to the owner two (2) copies of manufactures as-built design drawings including bill of material with part and catalog numbers.
1.3 STANDARDS
A. Comply with the following latest editions of standards as applicable:
   1. UL 891 Deadfront Switchboard
   2. NEMA PB-2 - Ground Fault Protection Devices
   3. NEMA SG3 - Low Voltage Power Circuit Breakers
   4. ANSI C37.90 - Relays and Relay Systems Associated with Electric Power Apparatus
   5. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment
   6. ANSI C37.13 - Low-Voltage AC Power Circuit Breakers Used in Enclosures
   7. ANSI C37.16 - Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
   8. ANSI C37.17 - Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
   9. ANSI C37.50 - Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
   10. UL 44 - Electric Wires and Cables
   11. UL 977 - Fused Power Circuit Devices
   12. IEEE Std. 242, Chapter 7 - Ground-Fault Protection

1.4 SEISMIC REQUIREMENTS
A. This panelboard is located in a seismic zone zero. Switchboard shall be constructed with all necessary bracing required for installation in specified seismic zone.

PART 2 - PRODUCTS

2.1 PANELBOARD CONSTRUCTION:
A. Panelboard assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL Standard 50 for cabinets. The size of wiring gutters shall be in accordance with UL Standard 67. Cabinets to be equipped with latch and tumbler-type lock on door of trim. Doors over 48" long shall be equipped with three-point latch and vault lock. All locks shall be keyed alike. Endwalls shall be removable. Fronts shall be of code gauge steel. Gray baked enamel finish electro-deposited over cleaned phosphatized steel.

B. The panelboard interior assembly shall be dead front with panelboard front removed. Main lugs or main breakers shall have barriers on five sides. The barrier in front of the main lugs shall be hinged to a fixed part of the interior. The end of the bus structure opposite the mains shall have barriers.

C. Panelboard bus structure and main breaker shall have current ratings as shown on the panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50 degrees C rise above ambient. Heat rise tests shall be conducted in accordance with Underwriters Laboratories Standard UL 67. The use of conductor dimensions will not be accepted in lieu of actual heat tests.

2.2 MISCELLANEOUS
A. Each panelboard, a complete unit, shall have a short circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or on the plans. This rating shall be established by testing with the overcurrent devices mounted in the panelboard. The short circuit tests on the overcurrent devices and on the panelboard structure shall be
made simultaneously by connecting the fault to each overcurrent device with the panelboard connected to its rated voltage source. Method of testing shall be per Underwriters Laboratories Standard UL 67. The source shall be capable of supplying the specified panelboard short circuit current or greater. Testing of panelboard overcurrent devices for short circuit rating only while individually mounted is not acceptable. Also, testing of the bus structure by applying a fixed fault to the bus structure alone is not acceptable. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be UL listed.

B. Provide UL listed ground sensor relay (GSR) system with Ground-Break components for main breaker, if 1000-amps or larger. Each unit shall consist of a coordinated ground sensor (CT) with integral test winding, solid state relay to operate shunt trip circuit on circuit protective device and Monitor panel. Relay shall be of the zone selective interlock type and have continuously adjusted current pick-up settings of 100-1200 ampere and continuously adjustable time delay setting from Inst. (.03 sec.) to 1 second. Relay shall provide two independent output contacts each rated five amperes continuous and 30 amperes inrush at (24, 36, 48, 125 V dc or 120, 120/208, 120/240 V ac). Relay shall include a memory function to recognize and initiate tripping on intermittent ground faults. Monitor panels shall indicate relay operation and provide means for testing system with or without interruption of service and must not permit ground fault system to be inadvertently left in an inactive or OFF state. Ground sensor shall be installed for ground return or zero sequence arrangement as required on main service device. On feeder and branch devices, furnish zero sequence sensor arrangements. System shall be G.E. type "Ground-Break" or equivalent by Square "D" Company.

C. All bussing shall be copper with silver plated connection points. Load connection points shall not exceed a 65°C temperature.

D. The thru bus shall be drilled and plated to allow for the addition of future sections.

E. The neutral bus shall be fully rated with bus material to match the main bus. Neutral bus shall be isolated from ground and drilled for field connection to Owner's grounding electrode system.

F. Finish shall consist of a rust resisting primer and an ANSI 61 light gray final coat.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:

1. Provide distribution and power panelboards as indicated in the panelboard schedule and where shown on the plans. Panelboards shall be equipped with thermal-magnetic, molded case circuit breakers of frame and trip ratings as shown on the schedule. Branch circuit breakers shall be Square “D” FA, KA, LA, MA, NH, PA and/or PC one, two or three pole molded case circuit breakers rated 15 through 2500 amperes, (120 V ac) (240 V ac) (277 V ac) (480 V ac), as specified on the drawings. Breakers shall be standard construction. All circuit breakers shall be UL and CSA listed, IEC 157-1 rated, meet NEMA Standard AB1-1975 and Federal Specification W-C-375B/GEN, when applicable. Molded case circuit breakers shall have over center toggle-type mechanisms, providing quick-make, quick-break action. Breakers shall be calibrated for operation in an ambient temperature of 40°C. Each circuit breaker shall have trip indication by handle position and shall be trip-free. Two and three pole breakers shall be common trip. Each circuit breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. Circuit breakers with frame sizes greater than 100 amperes shall have variable magnetic trip elements which are set by a single adjustment (to assure
uniform tripping characteristics in each pole). A push-to-trip button shall be provided on the cover from mechanically tripping the circuit breaker. The circuit breaker shall have reverse connection capability and be suitable for mounting and operating in any position. Unless otherwise indicated, branch circuit breakers up to 100 amperes shall have 10,000 RMS short circuit amperes symmetrical interrupting capacity. Circuit breakers above 100 ampere shall have 42,000 RMS capacity.

2. Overcurrent protection for feeders shall be provided by individually mounted molded case circuit breakers. Breakers shall be provided as indicated on drawings (80%/100%) equipped with adjustable solid state/digital long time pickup and delay, short time pickup and delay, and instantaneous pickup trip units. Provide zero sequence ground fault trip with adjustable pickup (100-1200A and adjustable time delay, minimum of 3 settings. Provide trip indicators for all functions. Breakers rated 600 volts with minimum interrupting rating of 42,000 rms symmetrical amperes at 480 volts. Breakers shall be plug-in connected or accepted equivalent. Equal breakers shall be General Electric "Spectra RMS", Siemens, "Sentron", or Cutler-Hammer/Westinghouse Electronic RMS.

2.4 ACCEPTABLE SWITCHBOARD MANUFACTURERS:

A. Square D
B. Siemens
C. Eaton
D. GE

PART 3 - EXECUTION

3.1 FACTORY TESTING:

A. Test the panelboard after fabrication at the factory as follows:
   1. Simulate all control and relay functions.
   2. Test complete operation of breakers including electric operation.

B. The Consultant's and the Owner's representative may witness factory tests, and review panelboard operation.
   1. Inform the Consultant two weeks prior to tests, and arrange for representatives to be present at the time of tests.
   2. The cost of Consultant's and Owner's expenses for the factory visit(s) will not be part of contract price.

3.2 FIELD TESTS AND TRAINING

A. Test new panelboard at the site before acceptance for service in accordance with manufacturer recommendations.

B. The Panelboard manufacturer shall furnish Owner's personnel operating and maintenance training at the site of the work for one (1) day at completion of construction. Time and date will be selected by Owner.

3.3 CABLE FEEDERS:

A. Cable feeders shall be tied to insulated cable supports and neatly formed and laced. Identify cable feeders in cable compartment with laminated nameplates (Reference Section 260553) fastened to cable circuits with nylon ties. Nameplates shall identify feeder and destination of
feeder; Reference Section 260553 “Identification for Electrical Systems” for further information.

3.4 INSTALLATION:

A. Secure each cubicle to the pad with a minimum of two 1/2” anchor bolts secured to the concrete pad, or other approved structure.

B. Provide all necessary bracing, additional anchors, etc. as required to secure panelboard for Seismic zone specified above.

C. Install switchgear as indicated on the drawings and in accordance with NEC article 384 and NECA standards of installation.

D. Provide a 4” high concrete housekeeping pad with leveling channels for switchboard installation.

E. Prior to energizing panelboard verify the following:
   1. Proper alignment and level of equipment
   2. Proper torque of all bolted connections
   3. Proper overcurrent device for load served
   4. Proper adjustment and operation of all mechanisms and accessories

F. Touch up, repair and replace any damaged surfaces and devices.

END OF SECTION 262213
SECTION 262300 - LOW VOLTAGE SWITCHGEAR

1.1 RELATED DOCUMENTS

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

B. The requirements as set forth in Division 26 COMMON WORK RESULTS FOR ELECTRICAL Section shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. Extent of switchgear work is indicated by drawings and schedules.

B. Section Includes:

1. Service and distribution switchgear rated 600 V and less.
2. Disconnecting and overcurrent protection devices.
3. Metering and instrumentation.
4. Accessory components and features.
5. Control power.

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section.

B. Product Data: Submit manufacturer's data on switchgear including dimensions and technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

C. Shop Drawings: Submit layout drawings of switchgear showing accurately scaled basic equipment Sections including auxiliary compartments, Section components, and combination Sections. Submittals shall also include:

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 bus configuration, current, and voltage ratings.
3. Include evidence of NRTL listing for series rating of installed devices.
4. Include schematic and wiring diagrams for power, signal, and control wiring.

D. Wiring Diagrams: Submit wiring diagrams for switchgear showing connections to electrical power feeders and distribution branches. Differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed.

E. Include evidence of NRTL listing for series rating of installed devices.

F. Ground-Fault: Submit complete set of details, wiring diagrams and basic information concern the ground-fault system. In addition to the equipment data provided manufacturer's recommended settings for all adjustable components of ground-fault equipment.
1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified and trained in electrical safety as required by NFPA 70E.

B. Manufacturer’s Qualifications: Firms regularly engaged in the manufacture of switchgear, of types, sizes and capacities required, and whose products have been in satisfactory use in similar service for not less than 5 years.

C. Firm with at least 5 years of successful installation experience on projects utilizing switchgear units similar to that required for this project.

D. Testing Agency shall be a member company of NETA or a NRTL. Field Supervisors shall be certified by NETA to supervise on-site testing.

E. Codes and Standards:

5. Comply with applicable local code requirements of the authority having jurisdiction, and the adopted electrical code as applicable to installation and construction of switchgear.
   a. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code" shall be used.

6. Comply with applicable requirements of UL 1558, "Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear" pertaining to installation and construction of switchgear. Provide switchgear and components which are NRTL listed and labeled.

7. Comply with applicable requirements of IEEE C37.20.1, "Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear" pertaining to switchgear.

8. Drawout type, unfused, power operated circuit breakers with electromechanical or electronic trip devices shall comply with IEEE C37.13, IEEE C37.13a, and UL 1066.

9. Surge Protection Devices where factory installed as an integral part of the switchgear, shall comply with UL 1449 (most recent edition).

10. Power Monitoring shall comply with UL 61010-1 "Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use".

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchgear and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for switchgear and components, which protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store switchgear equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors.

C. Handle switchgear equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

D. Do not store switchgear outdoors. When unavoidable, provide temporary, above grade enclosures to protect against weather, moisture and debris. Install temporary electrical heating within enclosure to prevent condensation.
1.6 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
2. Altitude: Not exceeding 6600 feet

B. Do NOT install switchgear in spaces until they are weather-tight and all wet areas within the space are dry. Field installed components of switchgear shall not be installed until all overhead work is complete and any dust from drywall work is complete in the area of installation.

1.7 SEQUENCING AND SCHEDULING

A. Schedule delivery of switchgear equipment, which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

B. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of switchgear with other work.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide switchgear products of one of the following (for each type and rating of panelboard and enclosure).

1. Eaton Corporation
2. General Electric Company
3. Siemen’s, ITE
4. Square D
B. While all manufacturers listed above are acceptable the electrical design is based on the use of Square D equipment. If an alternate manufacturer is submitted and approved it is the sole responsibility of the Contractor to ensure that the alternate equipment meets all of the requirements of the electrical specifications and drawings and that the physical equipment will fit in the space allotted on the site. Adjustments to the architectural or electrical drawings will not be made. All submittals of alternate equipment will be rejected unless a scaled drawing showing the submitted electrical equipment in the location indicated on the plans are submitted at the time of shop drawing review.

2.2 EQUIPMENT SECTIONS AND COMPONENTS

A. Except as otherwise indicated, provide switchgear and ancillary components of types, sizes, characteristics, and ratings indicated, which comply with manufacturer’s standard design, materials, components, and construction in accordance with published product information, and as required for complete installation.

1. All switchgear components shall be built, assembled and supplied by one manufacturer so there is one source of supply and responsibility.

B. AC Dead-Front Distribution Switchgear: Provide factory-assembled, dead-front, metal-enclosed, self-supporting secondary power switchgear, of types, sizes, electrical ratings and characteristics indicated; consisting of vertical panel units, and containing overcurrent assemblies of quantities, ratings and types indicated.

1. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker. Extend section barriers between main and tie circuit breakers to the rear of the section.
2. The following functions of circuit breakers shall be performed while the compartment door is closed:
   a. Review of circuit breaker nameplate.
   b. Adjustment of circuit breaker trip unit settings.
   c. Operate the manual charging station and ability to Open and Close the circuit breaker.
3. Install instrument compartments when additional space is required for metering and instrumentation. Allow for routing of instrumentation, control and communications wires, and cables.
4. Equip units with built-in lifting eyes and yokes; and provide vertical individual panel units, suitable for bolting together at project site.
5. Bus Material and Connections:
   a. Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections
   b. Use tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
   c. Use copper for connecting circuit-breaker line to copper bus.
   d. Contact Surfaces of Buses shall be silver plated.
   e. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
6. Neutral Disconnect Link: Bolted, uninsulated, bus, arranged to connect neutral bus to ground bus.
7. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
8. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
9. Brace bus for short-circuit stresses up to maximum interrupting capacity.
10. Provide accessibility of line and load terminations from front of switchgear.
11. Where spaces or blanks are indicated in the Construction Documents distribution compartments shall be equipped with mounting brackets, supports, bus connectors and other mounting accessories at full rating of distribution compartment.
12. Switchgear shall be front and rear accessible.
13. Refer to Construction Documents for nominal voltage rating, ampere and short-circuit withstand current ratings.
14. Neutral Bus shall be 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables.
15. Ground Bus: Hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
16. Main Phase Buses and Equipment Ground Buses shall be of uniform capacity the entire length of the main and distribution sections. All spaces in the distribution sections shall be bussed for future connections.
17. Construct switchgear for:
   a. Indoors (NEMA 1 or NEMA 250)
   b. Outdoors (NEMA 3R)
   c. Free standing
18. Enclosures: Suitable for floor mounting and conduit accessibility as indicated. Provide welded steel channel framework; removable and hinged rear panels for access to rear interior of switchgear. Coat enclosures with manufacturer's standard corrosive-resistant finish. For enclosures indicated as being outdoors the undersurfaces shall be treated with corrosion-resistant undercoating.

C. Circuit Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, disconnected, and withdrawn positions. Include the following features:
   a. Provide circuit-breaker racking system with positive stops at connected, test, disconnected, and withdrawn positions.
   b. Interlocks: Prevent racking of circuit breaker to or from connected position when it is closed and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
   c. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from connected, test, and disconnected positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit manual withdrawal of an open circuit breaker to a position for removal from the structure. When compartment door is open, status for connection devices for different positions includes the following:
      1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
d. Primary Disconnect: Mount on the stationary part of the compartment. Disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the connected position. Assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.

e. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of breaker.

f. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.

g. Place 2400-A frame and larger circuit breakers at the bottom of switchgear.

D. **Auxiliary Compartments:**

1. Where auxiliary compartments are included, they shall match and align with the entire switchgear assembly and lineup including:
   a. Utility metering compartments complying with utility company standards.
   b. Bus transition and incoming line pull sections.

E. Pull boxes mounted on top of the switchgear for additional area for pulling cables with removable covers and ventilation provisions to maintain adequate air temperature within same limits as switchgear.

1. Pull box shall be located to keep clear of circuit breaker lifting mechanism.

F. **Circuit Breakers:**


2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear. Comply with IEEE C37.16.

3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
   a. Normal Closing Speed: Independent of both control and operator.
   b. Slow Closing Speed: Optional with operator for inspection and adjustment.
      2) Electric Close Button: One for each electrically operated circuit breaker.
   c. Provide an interlock to discharge the stored energy mechanism before the circuit breaker can be withdrawn from its compartment.
   d. Operation counter.
G. Operator Display: Located on the face of the circuit breaker.

1. Electrical operation buttons to open and close the circuit breaker. Provide a clear lockable cover over the buttons.
2. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. An energized or hot condition shall be indicated by a red light. The de-energized, open, and safe condition shall be indicated by a green light.
3. Indicator to show the position of the circuit-breaker contacts, status of the closing springs, and circuit-breaker position in its compartment.
4. Provide a "charged-not OK to close" indicator when closing springs are charged but circuit breaker is not ready to close.

H. Overcurrent Protective Tripping: Microprocessor-based, programmable, time-current shaping adjustments; complete with current transformers and sensors and the following features:

1. Programmable functions independent of each other in both action and adjustment.
   a. Long-time setting.
   b. Long-time-delay with selectable I2T or I4T curve shaping.
   c. Short-time setting.
   d. Short-time-delay with flat or selectable I2T curve shaping.
   e. Instantaneous trip.
2. Field-adjustable, time-current characteristics.
3. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
4. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
5. Pickup Points:
   b. Five minimum, for instantaneous-trip functions.

I. Ground-Fault Protection:

1. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.
2. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

J. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.

K. Shunt-Trip Devices.

L. Metering:

1. Accuracy: 0.5 percent of reading, complying with ANSI C12.20.
2. Values shall be rms average over a period of one second.
   b. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
   c. Active Power (kW): Each phase and three-phase total.
   d. Reactive Power (kVAR): Each phase and three-phase total.
e. Apparent Power (kVA): Each phase and three-phase total.
f. Power Factor: Each phase and three-phase total.
g. Active Energy (kWh): Three-phase total.

M. Auxiliary Contacts:
2. Spare auxiliary switches, at least two, unless otherwise indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

N. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

O. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of draw out mechanism.

P. Key Interlocks: Arranged to prevent opening or closing of interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

2.3 ARC-FLASH LIMITING FEEDER CIRCUIT BREAKERS

A. Feeder circuit breakers shall be without current-limiting fuses, listed as complying with UL 1066.

B. Short-circuit withstand current rating shall be 200 kA.

C. Equip the arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as a temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.
1. Provide a manual switch on the compartment door to switch the circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting, to reduce the danger from potential arc-flash at downstream equipment.
2. Provide a lock feature for the switch so that it may be locked in either the off or on maintenance-mode position.
3. Provide a blue LED indicating light to indicate that the switch is in maintenance mode.

D. Provide dry relay contacts on each switch for annunciation of the switch position.

2.4 ZONE-SELECTIVE INTERLOCKING

A. Trip units for indicated circuit breakers shall include zone-interlocking capability for the short-time delay and ground-fault delay trip functions for system coordination and arc energy reduction. Zone-interlocking system shall restrain the tripping of an upstream circuit breaker and allow the circuit breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the preset time delay. Zone-interlock system shall be factory wired and tested for circuit breakers within the switchgear.
2.5 NETWORK PROTECTORS

A. Comply with IEEE 57.12.44 and IEEE C37.20.1. Switch shall comply with UL 1066.
   1. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Include mechanical interlocks to prevent racking in and racking out when protector is closed.
   2. Locate the relay and control panel on a separate drawout module.
   3. Protector Operator: stored-energy mechanism, rated to close on a 40,000-rms symmetrical load.
   4. Program the relay with factory-default values. Make provisions to field adjust these values using relay calibration procedures. Include an antipumping program to lock the protector open under abnormal conditions.
   5. Include current-limiting fuses on network side of protector for protection against switchboard bus faults.

B. Controls shall be via a microprocessor-based, three-phase network relay, with the following features and functions:
   1. Protector control shall use a positive and negative sequence-based algorithm for current and voltage.
   2. Close protector if positive sequence power flows into the network. Adjustable closing range shall be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
   3. Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
   4. Trip protector if there is a flow of reverse magnetizing current to its associated transformer.
   5. Relay parameters and watt or watt-VAr trip values shall be field adjustable.
   6. Protector shall not open under any fault on network side of protector.
   7. Include auxiliary contacts and control wiring for use with remote pilot devices that provide remote trip and lockout functions in low-voltage switchgear. Include two spare auxiliary contacts and an equal number of NO and NC types.

C. Communicate the following network relay parameters:
   1. Current in each phase.
   2. Phase-to-phase and phase-to-neutral voltages.
   3. Three-phase watts, VArS, and VA.
   4. Frequency.
   5. Power factor.

2.6 CONTROL POWER SUPPLY, 120-V AC

A. Control Power Transformer: Supply 120-V control circuits through dry-type control power transformers, include secondary disconnect devices.
   1. Place transformers larger than 3 kVA in separate compartments at the bottom of the vertical section, including the related primary and secondary fuses.
2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
   a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

2.7 CONTROL POWER SUPPLY, 24-V DC

A. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

B. Battery: Standard VRLA batteries, with battery disconnect and overcurrent protective device.

C. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads.

D. Accessories:
   1. Thermometers with specific-gravity correction scales.
   2. Hydrometer syringes.
   3. Set of cell numerals.

E. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.
   1. DC ammeter.
   2. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
   3. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
   4. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell, and equalizing charge at 2.33 V per cell.
   5. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.
   6. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.
   7. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. Device shall regulate charging current but shall not disconnect charger from either battery or ac supply.
   8. Charger’s Audible Noise: Less than 26 db.
2.8 INSTRUMENTATION AND CONTROL

A. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

B. Ethernet Connectivity:
   1. Install a multipoint, RS-485 Modbus serial communications network within the switchgear to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications.
   2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
   3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-TX LAN.
   4. Server Configuration:
      a. Initial network parameters set using a standard web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
      b. Network server shall be factory programmed with embedded HTML-formatted web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard web browser.
      c. Password-protected login, with password administration accessible from the LAN using a standard web browser.
      d. Operating Software: Suitable for local access; firewall protected.
   5. All serial communications devices within the equipment shall be addressed at the factory and tested.

C. Instrument Transformers: Comply with IEEE C57.13. Instrument transformers may not be used to power space conditioning equipment associated with outdoor switchgear, or for power to convenience receptacles and lighting.
   1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy class of 0.3 with burdens of W, X, and Y.
   2. Current Transformers: Burden and Accuracy class suitable for connected relays, meters, and instruments.

D. Analog Instruments: Rectangular, 4-1/2 inches square, 1 percent accuracy, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment.
   1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
   2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
   3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.

5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.

6. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
   a. Operation: Counts and records a succession of pulses entering two channels.
   b. Housing: Drawout, back-connected case arranged for semiflush mounting.

E. Power Monitoring: Separately mounted, modular, permanently installed, solid-state, digital I/O multifunction metering instrument for power and energy metering and monitoring, complying with UL 61010-1.

1. Capable of metering four-wire Y, three-wire Y, three-wire delta, and single-phase power systems.

2. Equipped with security lock to protect revenue-related metering from unauthorized and accidental changes.

3. Comply with IEC 60529 degree of protection code of IP65 for the front of meter, and code of IP30 for the body.

4. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

5. Accuracy:
   a. Comply with ANSI C12.20, Class 0.5.
   b. Neutral Current Measurement: Not more than 0.65 percent.
   c. Power Factor: 1.0 percent.
   d. Frequency: 0.1 percent.
   e. THD: 1.0 percent.
   f. Waveform Sampling: 64 per cycle.

6. Data Link: Ethernet connectivity specified in this article.

7. Meter Physical Characteristics:
   a. Display: Backlit LCD with antiglare and scratch-resistant lens.
   b. Display of Metered Values: One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
      1) All meters.
      2) Measurements.
      3) THD.
      4) Energy.
      5) Demand.
      6) Minimum and maximum values.
      7) Power demand.

8. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.

9. Meters:
   a. Instantaneous, rms:
      1) Current: Each phase, neutral and three-phase average.
      2) Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
3) Active Power (kW): Each phase and three-phase total.
4) Reactive Power (kVar): Each phase and three-phase total.
5) Apparent Power (kVA): Each phase and three-phase total.
6) Power Factor: Each phase and three-phase total.

b. Energy:
1) Active Energy (kWh): Three-phase total.

c. Demand, Derived from Instantaneous rms Meters:
1) Current: Present and maximum.
2) Active: Present and maximum.
3) Reactive: Present and maximum.
4) Apparent: Present and maximum.

d. Power Quality Measurements:
1) THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

10. I/O: Two optically isolated digital outputs for KYZ pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
   a. KYZ Pulse: Generate standard KYZ pulses for a user-defined increment of metered active energy as follows:
      1) User-defined pulse output, associated with kWh.
      2) User-defined pulse output, associated with kVarh.

11. Capacities and Characteristics:
   a. Circuit Connections:
      1) Overload Tolerance: 1500-V ac, rms, continuously.
      2) Current: Connect to instrument-grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
      3) Frequency: 45 to 65 Hz.
      4) Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.9 POWER TRANSFER CONFIGURATIONS

A. Factory-installed and -tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two power sources.

B. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

C. Control Wiring:
   1. Factory installed, complete with bundling, lacing, and protection.
   2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
   3. Install plugs in control wiring at shipping splits.
D. Two-Breaker Transfer Control:

1. Two-breaker transfer control shall provide for a switchgear assembly with a common load bus and one normally energized utility power source, designated "normal" and one normally de-energized generator source, designated "standby," connected to the load bus. Circuit breakers connecting the two power sources to the load bus shall be controlled by a microprocessor-based automatic transfer control. Power for the transfer control shall be from the voltage sensing transformers.

2. In automatic mode, the load bus is connected to the normal power source. When the normal source fails, the control shall automatically open the normal power source and close the standby source circuit breaker.

3. Sequence of Operation:
   a. Default operation shall be with the normal source main breaker closed and the standby main breaker open. On detection of an undervoltage to the line side of the normal main breaker and after a field-adjustable time delay (set at 5 seconds), that main breaker shall open and send a run signal sent to the paralleling switchgear. After an additional field-adjustable time delay (set at 5 seconds), the standby breaker shall close restoring power to the facility. (Refer to Paralleling Switchgear sequence of operations for additional information).
   b. On restoration of voltage to the line side of the normal main breaker and after a field-adjustable time delay (set to 30 minutes), the standby main breaker shall open and after a field-adjustable time delay (set to 5 seconds), the normal main breaker shall close.

4. Field-Adjustable Transfer Parameters:
   a. Delay the transfer from the normal power source to the standby power source and from the standby power source to the normal source. The time delay is to allow the load voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
   b. Delay the initiation of the transfer sequence. The time delay is recommended to override a momentary power outage or voltage fluctuation. Delay range: zero seconds to 120 seconds.
   c. Delay the transfer from the standby power source to the normal power source. Delay range: zero seconds to 30 minutes.
   d. A relay with contact that changes state when the power is available on the normal source and a relay with contact that changes state when the power is available on the standby source.

5. Controls and Indicators: Besides the delay setting controls, provide the following:
   a. Interlocks or relay control to prevent transfer when either of the two controlled circuit breakers are tripped due to overcurrent or ground fault.
   b. Two-position selector switch to select the normal source: Source 1 or none.
   c. Transfer-control automatic and manual selector.
      1) Interlock shall prevent paralleling of the two power sources in manual mode.
   d. Open-close control switch for manual electrical operation of each controlled circuit breaker.
   e. Selector to place control into programming mode.
   f. Circuit-breaker control switch for each of the normal and standby source breakers, providing open and close operation.
   g. Push button to initiate manual retransfer to the normal source when the transfer controller is in automatic mode.
   h. Meters and display to show the following:
1) Voltage and frequency of both sources.
2) A multiline display showing the following:
   i. Set points of timers, and voltage pickup and dropout set
      points.
   ii. Date, time, and reason for at least the last 10 transfers.
       Display may show the information for one transfer at a
       time using a scrolling control, with the others held in
       memory.
   iii. When the control system is in the transferring process,
       display shall show delay countdown in seconds.
   i. LED indicator lights to show the following:
      1) Normal source available.
      2) Standby source available.
      3) Normal source connected.
      4) Standby source connected.
      5) Load bus energized.
6. Voltage Transformers: Primary and secondary protection and disconnecting means
   for sensing functions and control power.
7. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection
   relays for three-phase undervoltage protection and negative sequence voltage
   protection.

2.10 DIFFERENTIAL GROUND-FAULT PROTECTION

A. Description: Ground-fault protection system for three-phase, four-wire switchgear having
   multiple sources shall be devised by manufacturer to ensure that the proper main or tie
   breaker(s) operate properly in normal and stand-by conditions. Switchgear shall include
   additional current transformers, ground-fault relays, interlocks, wiring, and accessories to avoid
   nuisance tripping of circuit breakers connected to the main bus of the switchgear. Ensure that
   the following occurs on the main bus:

1. A ground fault at any location in the switchgear shall trip the system.
2. Combination of normal current flow and ground-fault current flow shall trip the
   system.
3. Circulating currents through the neutral due to multiple grounds and sources
   external to the immediate low-voltage power sources shall not trip the system.
4. System shall not trip if there is no ground fault, during normal current flow.
5. System shall not trip due to large single-phase currents.

B. Relays: Comply with IEEE C37.90, with test blocks and plugs.

C. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges
   and for conductors for interconnections between shipping units.
3. Install plugs in control wiring at shipping splits.
2.11 MAINTENANCE TOOLS

A. Description: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

B. Include the following:

1. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
2. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
3. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
4. Racking handle to move circuit breaker manually between connected and disconnected positions.

C. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

D. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.12 IDENTIFICATION

A. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.
   a. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
      1) Location designation.
      2) Nominal voltage.
      3) Flash protection boundary.
      4) Hazard risk category.
      5) Incident energy.
      6) Working distance.
      7) Engineering report number, revision number, and issue date.
   b. Labels shall be machine printed, with no field-applied markings.

2.13 SOURCE QUALITY CONTROL

A. Testing: Test and inspect low-voltage switchgear according to IEEE C37.20.1. Drawout circuit breakers need not be tested in the assembly if they are tested separately.

1. Dielectric Tests: Perform power-frequency withstand tests to demonstrate the ability of the insulation system to withstand the voltages listed in IEEE C37.20.1. The voltage is to be increased gradually from zero to the required test value within 5 to 10 seconds and shall be held at that value for one minute.
2. Perform mechanical operation tests to ensure proper functioning of operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.

3. Test the effectiveness of grounding of each metal-case instrument transformer frame or case.

4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of component devices to ensure that they function properly and in the intended sequence.

5. Perform the control wiring insulation tests.

6. Verify correct polarity of the connections between instrument transformers and meters and relays.

B. All serial communications devices within the equipment shall be addressed at the factory and tested to verify reliable communications to the equipment's Ethernet gateway.

C. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which switchgear and components shall be installed and notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.2 INSTALLATION OF SWITCHGEAR

A. Install switchgear as indicated, in accordance with manufacturer’s written instructions, and with recognized industry practices; complying with applicable requirements and standards listed in Part 1 of this Section.

B. Install switchgear on reinforced concrete pad a minimum of 4” above finished floor. Switchgear shall be anchored to the concrete pad with epoxy coated anchor bolts.

C. Install manufacturer provided filler and blank plates in unused spaces to prevent access to live parts.

D. Complete switchgear grounding and surge-protector connections prior to making any other electrical connections

E. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque specified in UL Std. 486 A and B, and the adopted electrical code.

F. Each switchgear section must be bolted to the concrete floor slab using ¾”-10, Grade 2, bolts and conical washers torque to 70 pound feet. Exact quantity of bolts to be as required by switchgear manufacturer to provide a seismically qualified installation to withstand potential seismic forces up to Zone 4.
G. All switchgear shall be field marked to warn qualified persons of potential electric arc flash hazard. Marking shall be located so as to be clearly visible to qualified persons before examination, adjusting, servicing or maintenance of equipment. Marking shall be self-adhesive, commercial label conforming to adopted electrical code and A.N.S.I. Z535.4 as manufactured by Ideal or approved equal.

H. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit, where accessible, shall be identified by system. The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted at each branch-circuit switchgear or similar branch-circuit distribution equipment.

3.3 FIELD QUALITY CONTROL

A. Prior to energizing of switchgear, check all factory connections to ensure manufacturer’s torque tightening specifications. Items to check to include, but not limited to, bus-bar to bus-bar connections, conductor lugs to bus-bars, line-side bolts of circuit breakers and fusible switches where they attach to bus-bars.

B. Prior to energizing of circuitry, check all field connections to manufacturer's torque tightening specifications.

C. Prior to energizing of switchgear, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.

D. Prior to energizing, check switchgear for electrical continuity of circuits, and for short-circuits.

E. The ground-fault protection system shall be performance tested when first installed on site. The test shall be conducted in accordance with manufacturer's instruction, which shall be provided with the equipment. A written record of this test shall be made and submitted to the Engineers office.

1. At the completion of all tests, set all ground-fault settings as recommended by switchgear manufacturer.

3.4 TESTING

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Inspect bolted electrical connections for high resistance using one of the following two methods:

1. Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

D. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12
E. Visual and Mechanical Inspection:

1. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
2. Inspect insulators for evidence of physical damage or contaminated surfaces.
3. Verify correct barrier and shutter installation and operation.
4. Exercise active components.
5. Inspect mechanical indicating devices for correct operation.
6. Verify that filters are in place and that vents are clear.

F. Electrical Tests:

1. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the bus temperature is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.1.
   
   a. Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.1.
   
   b. Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

G. Perform a dielectric withstand voltage test on each bus section, phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

H. Perform insulation-resistance tests on control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's written instruction.

1. Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

I. Control Power Transformers:

1. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Insulation-resistance values of winding insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.1.

2. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
3. Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4. Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

J. Voltage Transformers:
1. Perform secondary wiring integrity test. Verify correct potential at all devices.
2. Verify secondary voltages by energizing the primary winding with system voltage.

K. Perform current-injection tests on the entire current circuit in each section of switchgear.
1. Perform current tests by secondary injection with magnitudes such that a minimum 1.0-A current flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

L. Perform system function tests according to “System Function Tests” Article.

M. Verify operation of space heaters.

N. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

O. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

P. Perform the following infrared scan tests and inspections and prepare reports:
1. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove panels so joints and connections are accessible to portable scanner.

Q. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

3.5 ADJUSTING AND CLEANING
A. Adjust operating mechanism for free mechanical movement.

B. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove paint splatters and other spots, dirt, and construction debris. Touch up scratches and mars of finish to match original finish.

3.6 GROUNDING
A. Provide equipment grounding connections for switchgear as indicated. Tighten connections to comply with tightening torque specified in UL Std 486A to assure permanent and effective grounds.
3.7 DEMONSTRATION:

A. Subsequent to wire and cable hook-ups, energize switchgear and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

B. Switchgear functions, controls and sequence of operations shall be tested with Owner and Engineer present to witness proper operation of equipment.

END OF SECTION 262300
SECTION 262413 - INTEGRATED POWER CENTER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. Furnish and install an integrated solution as specified herein and where shown on the associated schedules and drawings. The lineups shall include:

1. Power panel interiors
2. Lighting and Appliance panel interiors.
3. Integrated transformers

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and COMMON WORK RESULTS FOR ELECTRICAL Section.

B. Product Data: Approval documents shall include drawings that contain overall switchboard enclosure dimensions. The location of the main, branches, and solid neutral shall be shown clearly. In addition, the drawing shall illustrate one-line diagrams with applicable voltage systems.

C. Manufacturer shall provide installation instructions and NEMA Standards Publication PB 1.1 – “Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less”.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Wiring shall comply with:

1. Adopted Electrical Code
   a. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code” shall be used.

Manufacturer’s Qualifications: Company specializing in assembly of switchboard products with a minimum of twenty-five (25) years documented experience. The company that assembles and provides the integrated equipment enclosure(s) shall be the same company that manufactures the panelboards, circuit breakers and dry type transformers. Panelboards, overcurrent protective devices, components, and accessories shall be from a single source from single manufacturer.

B. Codes and Standards:

1. UL 50 – Standards for enclosures for electrical equipment
2. UL 67 – Standards for panelboards
3. UL 489 – Standards for molded-case circuit breakers
4. UL 508A – Standards for Industrial Controls
5. UL 891 – Standards for switchboards
6. NEMA AB 1 – Standards for molded case circuit breakers
7. NEMA PB 1 - Standards for panelboards
8. NEMA PB 2 – Standards for switchboards
9. NFPA 70 - National Electrical Code (NEC) - Switchboards and Panelboards
10. Federal Specification W-P-115C - Type I Class 1
12. ASCE 7 – American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures – Seismic compliance requirements

1.5 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
2. Altitude: Not exceeding 6600 feet

B. Do NOT install panelboards, switchgear or switchboards in spaces until they are weather-tight and all wet areas within the space are dry. Interiors to panels shall not be installed until all overhead work is complete and any dust from drywall work is complete in the area of installation.

1.6 COORDINATION

A. Contractor shall be responsible for coordinating final dimensions and locations of APPROVED panelboards, switchgear and switchboards for the installation of concrete pads. Concrete pads, reinforcement, etc. are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide panelboard products of one of the following (for each type and rating of panelboard and enclosure):
1. Eaton Corporation
2. General Electric Company
3. Siemens, ITE
4. Square D

B. Panelboards shall be the same manufacturer as other distribution equipment.

2.2 GENERAL REQUIREMENTS

A. The assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected to a power source having an available fault current and rated voltage, as shown on schedules.

B. The short circuit current rating of any section shall be limited to the lowest short circuit rating or series connected rating of any installed device in the section.
C. Bus bars shall be constructed of 98% copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65°C over a 40°C ambient (outside the enclosure).

D. Neutral bus shall be rated for 100% of phase bus rating. Provide suitable lugs for outgoing feeders requiring neutral connections.

E. A copper ground bus (minimum 1/4 x 2 inch), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

F. Where indicated on the drawings provide an insulated grounding bar for branch-circuit isolated ground conductors.

G. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

H. Enclosure:
   1. Each lineup shall consist of the required number of vertical sections bolted together to form a rigid assembly.
   2. All sections of the lineup shall be rear aligned with the depth as shown on the drawings and shall be front-accessible.
   3. NEMA Type 1 enclosures shall be constructed in accordance with UL 891 requirements.
   4. Enclosures shall have brushed and/or ANSI 49 gray enamel electrodeposited paint finish.
      a. All sections shall be aluminum except for those with transformers.
   5. Enclosure Depths
      a. NEMA Type 1 panel, contactor, BMS, third party equipment space sections shall be 11 inches maximum.
      b. NEMA Type 1 Transformer Assembly sections shall be 24” deep or 36” deep depending on the size, type and rating of the transformer(s).
   6. Enclosure Height
      a. All panel, contactor, BMS, third party equipment space sections shall be 84” high maximum. When enclosure extensions are required these sections shall be 91” maximum
      b. Transformer Assembly sections shall be 91.5” high maximum as standard.
   7. Single section shipping splits shall be 48 in. wide maximum.
   8. Multiple section shipping splits shall be 88 in. wide maximum.

I. Enclosure Construction:
   1. Trim front shall meet strength and rigidity requirements of applicable UL standards.
   2. Each section shall have a full height hinged door with a three-point latch.
   3. The latch shall have a cylindrical tumbler type keyed lock.
   4. Each latch shall also have Lock-out Tag-out provisions
   5. All lock assemblies shall be keyed alike. One (1) key shall be provided with each lock.
   6. Full height door shall have lift off hinges to facilitate maintenance.
   7. Directory cardholder with typed circuit directory shall be included with each panel interior.
   8. The manufacture shall provide a hinged door with a [quarter-turn latch] or [lockable latch] over the deadfront of each panelboard interior.

J. Short-circuit ratings shall be determined from the Coordination Study. Short-circuit rating shall be a minimum of 10,000AIC for 208V systems and 14,000AIC for 480V.
1. Available Fault Current values shown on the drawings are estimates only and do not take into account breaker coordination.

K. Where “Space”, “Space Only” or another indication in the panel schedule is shown to reflect a future device, provide the proper bus connection, mounting brackets, blank plates so a future device can be installed.

L. Panelboards shall be fully rated unless otherwise indicated on the plans.

2.3 WIRING/TERMINATION

A. Factory installed type THHN power cables shall electrically connect the power panel interiors, lighting and appliance panel interiors and transformers in the lineup.

B. Wire markers shall be provided at each end of the control wiring for lighting contactors and Terminal blocks shall be clearly labeled.

C. When shipping splits are required, power cables shall be cut to length, stripped, labeled and rolled back in one of the adjacent enclosures. Control cables that bridge shipping splits shall be provided with male/female connectors.

D. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s wiring diagrams.

E. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.

F. All connectors shall be suitable for both aluminum and copper conductors.

G. All connections shall be mechanical type (No compression type connections).

H. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

I. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

J. The distribution panel and/or switchboard manufacturer shall wire all panelboards from the associated feeder breaker (in the Main section of the switchboard) to the panelboards and/or transformers as noted on drawings. This wiring be installed in the factory and shall not installed in the field.
2.4 PANEL INTERIORS

A. Panel interiors shall be flush mounted with the front of the enclosure to allow easy access to line and/or load conductor’s entering/exiting top or bottom. Recessing the panel interior more than 3 inches from the front of the enclosure will not be acceptable.

B. If two 42-circuit panel interiors are stacked in the same vertical section, a horizontal barrier that complies with UL 891 requirements shall separate the panel interiors.

2.5 CIRCUIT BREAKERS

A. Refer to 262416 – PANELBOARDS section for additional information.

2.6 Integrated Transformer(s)

A. Shall be Non-Linear, dry type transformer(s).

B. Transformer coils shall be copper wound construction and shall be impregnated with non-hygroscopic thermosetting varnish.

C. Transformers shall have electrostatic shield

D. Transformer(s) shall be factory installed in a common freestanding enclosure as shown on the associated drawings.

E. Transformers kVA rating as specified on the drawings. - Refer to 262200 LOW-VOLTAGE TRANSFORMER Specifications for additional requirements.

F. Fan cooled transformers will not be allowed.

PART 3 - EXECUTION

3.1 INSTALLATION OF PANELBOARDS

A. The Contractors shall install all equipment per the manufacturer’s instructions, contract drawings and adopted electrical code.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills provided the floor is level to 1/8 inch per 3-foot distance in any direction. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

C. Provide and affix typewritten directory to inside cover of panelboard indicating loads controlled by each circuit.

D. Install the Integrated Power Center in accordance with manufacturer’s written instructions, NEMA PB 2.1 “Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 volts or Less” and NEC standards.
E. Every circuit and circuit modification shall be legibly identified in a circuit directory. Circuit directory shall be neatly typed and mounted on the inside of door, designating the room numbers, outlets, lights, receptacles and motors served by each branch circuit. Room numbers shown on the plans and panelboard schedules are the design room numbers. Room numbers typed into the circuit directory are to be Actual Room numbers used in building. Verify numbers with Architect.

F. All panelboards shall be field marked to warn qualified persons of potential electric arc flash hazard. Marking shall be located so as to be clearly visible to qualified persons before examination, adjusting, servicing or maintenance of equipment. Marking shall be self-adhesive, commercial label conforming to adopted electrical code and A.N.S.I. Z535.4 as manufactured by Ideal or approved equal.

3.2 ADJUST AND CLEAN

A. Contractor to clean inside of all enclosures prior to pulling conductors and installing interior components of panelboards.

B. Inspect circuit-breaker-operating mechanisms for malfunctioning and, where necessary, adjust unit for free mechanical movement.

3.3 GROUNDING

A. Provide equipment grounding connections for panelboards as indicated. Tighten connections to comply with tightening torques specified in UL Stds. 486A and B to assure permanent and effective grounds.

3.4 FIELD QUALITY CONTROL

A. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification.

B. Prior to energizing of overcurrent protective devices, test devices for continuity of circuitry and for short-circuits. Correct malfunctioning units, and then demonstrate compliance with requirements.

C. Prior to energizing of panelboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.

D. Prior to energizing, check panelboards for electrical continuity of circuits, and for short-circuits.

E. Subsequent to wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

F. Perform the following infrared scan tests and inspections and prepare reports:

1. Infrared Scanning: Perform an infrared scan of each panelboard after Substantial Completion, but not more than 60 days after Final Acceptance.

3.5 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards:
1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground.

B. The manufacturer shall provide three (3) certified copies of factory test reports.

3.6 MANUFACTURER'S CERTIFICATION

A. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.7 FIELD QUALITY CONTROL

A. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.

1. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications

END OF SECTION 262413
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements as set forth in Division 26 COMMON RESULTS FOR ELECTRICAL Section shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. Extent of panelboard and enclosure work, including cabinets and cutout boxes, is indicated by drawings and schedules, and as specified herein.

B. Types of panelboards and enclosures required for the project include the following:

C. Power Distribution Panelboards

D. Lighting and Appliance Branch-Circuit Panelboards

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section.

B. Product Data: Submit manufacturer’s data on panelboards including: amperes, voltages and current ratings, interrupting ratings, mounting requirements, physical dimensions and auxiliary components.

C. Include evidence of NRTL listing for series rating of installed devices.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Wiring shall comply with:

   1. Adopted Electrical Code
      a. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code" shall be used.

B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
C. Panelboards, overcurrent protective devices, components, and accessories shall be from a single source from single manufacturer.

D. Codes and Standards:
1. Comply with applicable local code requirements of the authority having jurisdiction and the adopted electrical code as applicable to installation, and construction of electrical panelboards and enclosures.
2. Comply with applicable requirements of UL 67, "Electric Panelboards," and UL's 50, 67, 869, 486A, 486B, and 1053 pertaining to panelboards, accessories and enclosures. Provide panelboard units, which are NRTL-listed and labeled. Complying with applicable requirements of UL 489, “Molded-Case Circuit Breakers”.
3. Provide panelboards, constructed for special-use, with appropriate NRTL markings, which indicate that they are suitable for special type of use/application.

1.5 FIELD CONDITIONS
A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
   a. Altitude: Not exceeding 6600 feet

B. Do NOT install panelboards, switchgear or switchboards in spaces until they are weather-tight and all wet areas within the space are dry. Interiors to panels shall not be installed until all overhead work is complete and any dust from drywall work is complete in the area of installation.

1.6 COORDINATION
A. Contractor shall be responsible for coordinating final dimensions and locations of APPROVED panelboards, switchgear and switchboards for the installation of concrete pads. Concrete pads, reinforcement, etc. are specified in Division 3.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide panelboard products of one of the following (for each type and rating of panelboard and enclosure):

1. Eaton Corporation
2. General Electric Company
3. Siemens, ITE
4. Square D

2.2 GENERAL REQUIREMENTS

A. Except as otherwise indicated, provide panelboards, switchgear, and switchboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials; with the design and construction in accordance with published product information; equip with proper number of unit panelboard devices as required for complete installation. Where types, sizes, or ratings are not indicated, comply with adopted electrical code, UL and established industry standards for those applications indicated.

B. All panelboards, switchgear, and switchboards components shall be built, assembled and shipped by one manufacturer so there is one source of supply and responsibility.

C. As indicated on the drawing's panelboards shall either have a main circuit breaker to protect and de-energize the phase buses or be main lug only with protection being provided from an upstream distribution. Main fusible switches are not acceptable.

D. Bus bar connections to all circuit breakers shall be bolt-on type. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type.
   1. Single phase, three-wire panelboard bussing shall be such that any two adjacent single-pole breakers are connected to opposite polarities in such a manner that two-pole breakers can be installed in any location.
   2. Three-phase, four-wire panelboard bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three-pole breakers can be installed at any location.
   3. All current carrying parts of the bus assembly shall be plated.

E. Enclosure Ratings:
   1. NEMA 1, NEMA 250 – Interior Locations.
   2. NEMA 3R, NEMA 250 – Exterior Locations.
   3. NEMA 4X, NEMA 250 – Kitchens, areas of wash down or other interior wet locations
4. NEMA 12, NEMA 250 – Indoor locations subject to falling dirt and noncorrosive liquids

F. Enclosure Construction:
1. Panelboards shall have a door-in-door trim where a piano hinge is installed down one side and the other side secured with screws that will allow access to the interior parts of the panelboard, and a lockable, interior door allows access to the circuit breakers.
2. Where doors are longer than 36” they shall have two latching mechanisms keyed alike.
3. Equip with interior circuit-directory frame, and card with clear plastic covering.
4. Provide manufacturer’s standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat

G. Short-circuit rating shall be a minimum of 10,000AIC for 208V systems and 14,000AIC for 480V.
1. Available Fault Current values shown on the drawings are estimates only and do not take into account breaker coordination.

H. Short-circuit values are shown on the drawings. Panelboards and distribution panels shall have a rating equal or higher than what is shown on the plans with a minimum of 10,000AIC for 208V systems and 14,000AIC for 480V.

I. Phase, Neutral and Ground Buses:
1. Buses shall be tin-plated aluminum.
2. Bus assembly shall be designed for a maximum temperature rise of 55 degrees C above 40 degrees C ambient temperature when carrying rated current.
3. Minimum thickness of bus bars shall be 3/32”.
4. Bussing shall be braced to withstand a fault current equal to the highest device interrupting capacity in the panel.
5. Neutral bus shall be rated for 100% of phase bus rating. Provide suitable lugs for outgoing feeders requiring neutral connections.
6. Where indicated on the drawings, a neutral rated for 200% of the phase bus shall be provided. Neutral bus shall be UL listed as suitable for non-linear loads.
7. Provide a bare uninsulated grounding bar suitable for bonding to enclosure.
8. Where indicated on the drawings provide an insulated grounding bar for branch-circuit isolated ground conductors.

J. Conductor Connectors:
1. All connectors shall be suitable for both aluminum and copper conductors.
2. All connections shall be mechanical type (No compression type connections).
K. Temperature Ratings: All conductor terminals and equipment enclosures to be U.L. Listed for use with minimum 75°C rated conductors.

L. Panelboards used as Service Entrance equipment to be NRTL labeled for the installation and provided with all necessary bonding straps required to comply with Code.

M. Where “Space”, “Space Only” or another indication in the panel schedule is shown to reflect a future device, provide the proper bus connection, mounting brackets, blank plates so a future device can be installed.

N. Panelboards shall be fully rated unless otherwise indicated on the plans.

O. Where contactors are indicated as being integral to panelboards and connected to the main bus they shall be electrically held, Class A type with the same short-circuit interrupting capacity as the panelboard meeting the requirements of NEMA ICS 2.

P. Load Centers are not approved for this project.

2.3 CIRCUIT BREAKERS

A. General: Except as otherwise indicated, provide circuit breakers and ancillary components, of types, sizes, ratings and electrical characteristics indicated, which comply with manufacturer's standard design, materials, components, and construction in accordance with published product information, UL 489 and as required for a complete installation.

B. Molded-Case Circuit Breakers:
   1. Provide factory-assembled, molded-case circuit breakers of frame size, pole and ampere rating indicated. Construct with over center, trip-free, toggle type operating mechanisms with quick-make, quick-break action and positive handle indication.
   2. Construct breakers for mounting and operating in any physical position and operating in an ambient temperature of 40°C.
   3. Breakers shall have mechanical screw type removable connector lugs, AL/CU rated and be bolt-in type construction.


D. Electronic Trip: Field adjustable settings for instantaneous trip, pickup levels, time adjustments and GFCI adjustments including time delay (where breakers are indicated on the plans to have GFCI protection). Breaker shall include an interchangeable rating plug that can be replaced in the field.

E. Circuit breakers used on heating, air conditioning, or refrigeration equipment shall be type “HACR” and U.L. listed for such use.
F. **GFCI Circuit Breakers:** Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

G. **Ground-Fault Equipment Protection (GFEP) Circuit Breakers:** Class B ground-fault protection (30-mA trip).

H. **Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers:** Comply with UL 1699; 120/240-V, single-pole configuration.

I. Interrupting Ratings of breakers shall meet or exceed the AIC rating shown on the drawings with a minimum of 10,000 RMS for 208V systems and 14,000 RMS for 480V.

J. For breakers 100A and larger provide with a handle padlocking device with fixed attachment, for locking circuit-breaker handle in on or off position.

K. For breakers smaller than 100A and shown on the plans as being locked in the on or off position, provide a handle clamp as a loose attachment.

**PART 3 - EXECUTION**

**3.1 INSTALLATION OF PANELBOARDS**

A. **General:** Install panelboards and enclosures where indicated, in accordance with manufacturer’s written instructions, applicable requirements of the adopted electrical code and NECA 407 and NEMA PB1.1, and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. **Tighten connectors and terminals,** including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Where manufacturer’s torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds. 486A and B.

C. **Anchor enclosures firmly to walls and structural surfaces,** ensuring that they are permanently and mechanically secure.

D. **Provide electrical connections within enclosures.**

E. **Every circuit and circuit modification shall be legibly identified in a circuit directory.** Circuit directory shall be neatly typed and mounted on the inside of door, designating the room numbers, outlets, lights, receptacles and motors served by each branch circuit. Room numbers shown on the plans and panelboard schedules are the design room numbers. Room numbers typed into the circuit directory are to be Actual Room numbers used in building. Verify numbers with Architect.
F. All panelboards shall be field marked to warn qualified persons of potential electric arc flash hazard. Marking shall be located so as to be clearly visible to qualified persons before examination, adjusting, servicing or maintenance of equipment. Marking shall be self-adhesive, commercial label conforming to adopted electrical code and A.N.S.I. Z535.4 as manufactured by Ideal or approved equal.

G. Where panelboards are recessed into walls provide four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

3.2 INSTALLATION OF CIRCUIT BREAKERS

A. Install overcurrent protective devices as indicated, in accordance with the manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with the adopted electrical code and NEMA standards for installation of overcurrent protective devices.

B. Fasten circuit breakers without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.

C. Install breakers from top to bottom, located and numbered with spare and spaces per the panel schedules. This must be done to maintain balanced loads on panelboard feeders.

3.3 ADJUST AND CLEAN

A. Contractor to clean inside of all panelboard enclosures prior to pulling conductors and installing interior components of panelboards.

B. Inspect circuit-breaker-operating mechanisms for malfunctioning and, where necessary, adjust units’ for free mechanical movement.

C. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove paint splatters and other spots, dirt, and construction debris. Touch up scratches and mars of finish to match original finish.

3.4 GROUNDING

A. Provide equipment grounding connections for panelboards as indicated. Tighten connections to comply with tightening torques specified in UL Stds. 486A and B to assure permanent and effective grounds.
3.5 FIELD QUALITY CONTROL

A. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification.

B. Prior to energizing of overcurrent protective devices, test devices for continuity of circuitry and for short-circuits. Correct malfunctioning units, and then demonstrate compliance with requirements.

C. Prior to energizing of panelboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.

D. Prior to energizing, check panelboards for electrical continuity of circuits, and for short-circuits.

E. Subsequent to wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

F. Perform the following infrared scan tests and inspections and prepare reports:
   1. Infrared Scanning: Perform an infrared scan of each panelboard after Substantial Completion, but not more than 60 days after Final Acceptance.

END OF SECTION 262416
SECTION 262726 – WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This Section includes the following:

1. Floor Service Receptacles
2. Ground Fault Circuit Interrupter Receptacles
3. Lighting and Equipment Switches
4. Manual Dimmers
5. Multi-Outlet Assemblies
6. Receptacles
7. Wall Plates

1.2 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section.

B. Product data for each type of product specified.

1.3 QUALITY ASSURANCE

A. Adopted electrical code.

1. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code" shall be used.

B. Provide wiring devices which are listed and labeled by NRTL and comply with applicable UL and NEMA standards.

1. UL 498 (and supplements).

1.4 SEQUENCE AND SCHEDULING

A. Schedule installation of finish plates after the surface, upon which they are installed, has received final finish.
PART 2 - PRODUCTS:

2.1 MANUFACTURERS

A. Wiring Devices and Accessories:
   1. Cooper Wiring Devices
   2. EGS/Appleton
   3. Hubbell Inc.
   4. Leviton Manufacturing Company Inc.
   5. Pass and Seymour Inc.

B. Floor Boxes:
   1. American Electric, Steel City
   2. Raceway Components Inc.
   3. Raco Inc., Hubbell Inc.
   4. Walker/Wiremold Company

C. Dimmers:
   1. Hubbell Inc.
   2. Leviton Manufacturing Company Inc.
   3. Lutron Lighting

D. Plugmold and Tele-Power Poles:
   1. Mono Systems Inc.
   2. Walker/Wiremold Company

E. Surge Suppressors: (Receptacle devices only)
   1. Cooper Wiring Devices
   2. Crouse-Hinds
   3. Hubbell Inc.
   4. Leviton Manufacturing Company Inc.
   5. Pass and Seymour Inc.
2.2 WIRING DEVICES

A. All wiring devices are to be provided by the same manufacturer unless noted otherwise.

B. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are NRTL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. All devices to be specification grade (Heavy Duty U.L. grade), with green hexagonal equipment ground screw, metal plaster ears and side terminal screws for back and side wiring.

C. Device and coverplate colors shall be:
   1. Ivory.
   2. White - Where installed in white ceilings.

2.3 STRAIGHT BLADE RECEPTACLES

A. Single receptacle, 15 Amp, 125 Volt, 2-pole, 3-wire, grounding type with NEMA configuration 5-20R, meets Federal Spec. WC-596-F. Leviton #5261.


C. Duplex receptacle, 20 Amp, 125 Volt, 2-pole, 3-wire, grounding type with NEMA configuration 5-20R, meets Federal Spec. WC-596-F. Leviton #5352.

D. Ground-Fault Interrupter receptacle, 20 Amp, 125 Volt, 2-pole, 3-wire, grounding type with NEMA configuration 5-20R. UL943 approved, self-testing, solid state ground-fault sensing level with 5 milliamperes ground-fault trip level. LED indicator light with Test/Reset buttons that match the color of the face. Leviton #G5362-WT*.
   1. GFCI devices shall NOT be wired to protect devices downstream unless specifically called for on the drawings.

E. USB receptacle, 20A, 125V, 2-pole, 3-wire, grounding type with NEMA configuration 5-20R, (2) vertical USB ports with 3.6A charging capacity (minimum), meets Federal Spec. WC-596-F. Leviton #T5832
   1. Where shown as a quad receptacle on plans, provide (2) USB receptacles as specified above.

F. Controlled receptacle, 20A, 125V, 2-pole, 3-wire, grounding type with NEMA configuration 5-20R, permanently labeled with controlled symbol, meets Federal Spec. WC-596-F. Leviton #5362-2.
1. Where shown as a quad receptacle on plans, provide (1) Controlled receptacle and (1) Duplex receptacle as specified above.

G. Weatherproof receptacle shall be a ground-fault interrupter with Thomas & Betts #CKSUV (or CKMU for horizontal mounting) die-cast aluminum “Small” cover plate. Locate box vertical in wall. Plate to be listed and labeled “Suitable for Wet Locations While in Use”.

H. Isolated ground duplex receptacle, 20-amp, 125-volt, 2-pole, 3-wire, with orange triangle, ground screw isolated from mounting yoke, NEMA configuration 5-20RIG. Leviton #5362-IG.

I. Hospital Grade Receptacles: Shall match configuration of all convenience outlets. Identification shall be provided by green dot on receptacle face. Receptacle body shall be of high impact thermoplastic and face shall be high strength nylon. Leviton 8300. Hospital Grade ground fault receptacle to be Leviton #8898-HG.

J. Tamper-proof Receptacles: Shall be provided in all pediatric rooms and wards, and all other locations where children might be present in noted locations. Receptacle rated 20-amp, 125 volt, 2-pole, 3-wire. Leviton TRB-20.

K. Heavy duty receptacles shall be of the same manufacturer as the convenience outlets and have the ratings and characteristics (voltage, amps, poles, wires) as shown on Drawings.

L. Cord and Plug: Shall have a matching plug and receptacle type connector, NEMA 5-20 (unless otherwise noted on plans), heavy duty grade.

1. Where the cord is suspended from the above the cable shall be provided with a woven wire mesh cable grip of high-strength, galvanized steel of the same diameter as the cable and the plug and receptacle shall be NEMA L5-20 (unless otherwise noted on plans), heavy duty type.

2.4 SWITCHES


B. Key type switch, 20-amp, 120/277-volt AC single-pole, with mounting yoke insulated from mechanism, equipped with plaster ears, side-wired screw terminals, polished metal top and provide with one steel key. Leviton #1121-2L.

1. Double-pole, 3-way, and 4-way switches shall be of the same make as for single-pole.
2.5 FLOOR BOXES

A. Type ‘FB’: Hubbell #B-4233, rectangular double-gang, fully adjustable, watertight box with (6) 3/4" threaded access holes and one S-3825 duplex flap cover complete with one 20 amp, 125 volt duplex brown receptacle as specified under "Receptacles". Also provide one #S-2625 cover plate with one #S-3061 protective ring for protection of telephone/computer cables. Box cover plates shall be brass. Cover to be provided with brass carpet flange for flush installation in linoleum, wood or carpet floors.

B. Type 'FD': Hubbell #B-4233, rectangular double-gang, fully adjustable, watertight box with (6) 3/4" threaded access holes and two S-3825 duplex brass flap covers, and two 20-amp, 125 volt duplex brown receptacles as specified under "Receptacles". Box cover plates shall be brass. Cover to be provided with brass carpet flange for flush installation in linoleum, wood or carpet floors.

2.6 MULTI-OUTLET ASSEMBLIES

A. Raceways shall be two-piece non-metaltic, dual channel assembly with an internal divider. Raceway shall have (1) 20A., 125 volt, 2-pole, 3-wire receptacle every 24" OC unless otherwise noted on the plans. Every 36" OC an outlet shall be installed for installation of data/communication outlets. Color options shall be verified with Architect prior to product ordering. Electrical contractor is responsible for providing all parts for a complete installation. Wiremold 5500 Series Raceway shall be used for minimum product standards.

2.7 MISCELLANEOUS OUTLETS, DEVICES AND EQUIPMENT

A. Drinking fountain outlet: Contractor shall check with the Plumbing Contractor for unit being furnished and install the receptacle inside of enclosure.

1. Receptacle shall NOT be GFCI type but shall be protected with a GFCI breaker in the supplying panelboard.

B. Telephone outlets: Wall telephone outlets shall be two-gang box with single-gang ring. Provide blank plate if phone outlet is not installed.

C. Technology/Computer Outlet: Outlet to be a two-gang, 3" deep box with a single-gang ring. Provide blank cover plate on box.

2.8 WIRING DEVICE ACCESSORIES

A. Wall plates: Single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide plates which mate with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads to match finish of plates. Provide wall plates with engraved legend where indicated.
1. **Material and Finish:** 0.04-inch-thick, type 430, satin-finished stainless steel, (all indoor application except where noted otherwise).
2. **Material and Finish:** Smooth plastic.
3. **Material and Finish:** 0.04-inch-thick, type 302 satin-finished stainless steel. (Outside applications).
4. **Material and Finish:** 0.04-inch-thick, type 302 satin-finished stainless steel. (Kitchen, cafeteria applications not including breakrooms or coffee stations).
5. **Material and Finish:** Steel plate, galvanized.

**PART 3 - EXECUTION**

**3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES**

A. Install wiring devices and accessories as indicated, in accordance with manufacturer’s written instructions, applicable requirements of the electrical code and in accordance with recognized industry practices to fulfill project requirements.

B. Location of wiring devices on small scale drawings are approximate and exact dimensions for location of outlets shall be taken from large scale plans and details on drawings or as directed by the Architect. Outlets shall be located generally from column centers and finished wall lines or to centers of acoustical and decorative ceiling panels and to centers of joints of wall panels.

C. Groups of switches or switch and outlet combinations shall be mounted under one cover plate. Cover plates shall fit the devices securely and shall cover the wall opening completely to provide a neat and finished appearance flush with surrounding surfaces.

D. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.

E. Install wiring devices only in electrical boxes, which are clean, free from building materials, dirt, and debris.

F. 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.

G. Install galvanized steel wallplates in unfinished spaces.

H. Install wiring devices after wiring work is completed. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

I. Install wall plates after painting work is completed.

J. Terminals on all wiring devices shall not be used to feed through to the next devices.
K. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque-tightening values for wiring devices. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

L. Install wall-mounted receptacles with ground slot up.

M. Receptacle mounted above counter-top to be installed horizontal, with long dimension parallel to floor and counter-top and grounding pin on the right.

N. Surface mounted multi-outlet assemblies to be secured to surfaces using toggle bolts for hollow wall construction or wood screws when attached to casework. Support screws to be located on maximum 18" centers and on each end. Install all necessary couplings, covers, fittings, elbows, corner pieces, grounding clamps and other necessary hardware for a complete installation. All raceway cuts to be made using factory approved tools for a clean and finished appearance.

O. Install recessed floor boxes by securing box and attached conduits to subgrade soil. Attachment to be accomplished by driving anchors through the gravel and a minimum of 12 inches into compacted soil below. Secure adequately to prevent boxes from shifting location during pouring of concrete.

3.2 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. Switches: Where 3 or more switches are ganged, and elsewhere where indicated, identify each switch with approved legend engraved on wall plate.

1. Receptacles: Identify the panelboard and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

END OF SECTION 262726
SECTION 262813 - FUSES

PART 1 - FUSES

1.1 RELATED DOCUMENTS

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

B. The requirements as set forth in Division 26 GENERAL ELECTRICAL REQUIREMENTS Section shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. Drawings and schedules indicate extent of fuses required.

B. Types of fuses in this Section include the following:
   1. Class RK-1 – Fast Acting
   2. Class L – Fast Acting
   3. Class RK-5 – Duel –Element

C. Refer to other Sections for switchboards and circuit & motor disconnects; Work required in conjunction with fuse devices; not Work of this Section.

D. Spare Fuse Cabinet

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section

B. Product Data: Submit manufacturer's data on fuses, including; amperes, voltages and current ratings, interrupting ratings, current limitations, time-current characteristic curves, and mounting requirements

C. Include dimensioned drawings including materials, components and finish options for fuse cabinet.

1.4 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of fuses, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer: Qualified with at least five (5) years of successful installation experience on projects with electrical installation work similar to that required for project.

C. Comply with adopted electrical code requirements as applicable to construction and installation of overcurrent protective devices.
D. Compliance: Devices shall be Listed and Labeled by a qualified testing agency and marked for the devices intended purpose and application.

E. NEMA Compliance: Comply with applicable requirements of NEMA pertaining to fuse mounting arrangement.

1.5 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 (3) of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 degrees F or more than 100 degrees F, apply manufacturer’s ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products of one of the following (for each type and rating of overcurrent protective device):
   1. Copper Bussmann
   2. Littlefuse Inc.
   3. Mersen (Ferraz Shawmut Inc.)

2.2 FUSES

A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time/current and peak let-through current characteristics indicated, which comply with manufacturer’s standard design, materials, and construction in accordance with published product information, and with industry standards and configurations. All fuses to be for use with fuse rejection clips.

B. All fuses shall be of the same manufacturer to insure selective coordination.

C. Service entrance and feeder circuits 601 amperes and larger: Fuses shall be bolt-on UL listed Class L, current-limiting with 200,000 amperes R.M.S. symmetrical interrupting rating.

D. Feeder circuits, except motor circuits, 600 amperes and smaller: Plug-in cartridge UL Class RK-1, current-limiting with 200,000 amperes R.M.S. symmetrical interrupting rating.
E. Motor, transformers, and inductive type circuits 600 amperes and smaller: Plug-in cartridge UL Class RK-5 dual-element with time delay. They shall also have current-limiting links and 200,000 amperes interrupting rating. Fuse reducers shall be used where switch fuse clips are spaced larger than fuse size shown on Drawings.

F. Plug fuses for individual motor protection shall be dual-element, 10,000 amperes R.M.S. symmetrical interrupting rating, type "S" with Fustat Adapter sized for plug-fuse installed. Size of fuse to be according to specifications for "Enclosed Switches and Circuit Breakers".

G. Fuse Cabinet: Sized adequately for spare fuses with 20% spare capacity, constructed of 0.08 aluminum (minimum), gray enamel finish, cylinder type lock and piano hinged door.

PART 3 - EXECUTION

3.1 INSTALLATION OF FUSES

A. Install fuses as indicated, in accordance with the manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with adopted electrical code and NEMA standards for installation of fuses.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Coordinate with other work, including electrical wiring installation, as necessary to interface installation of fuses with other work.

D. Install fuses with manufacturer’s nametag facing outward.

E. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

F. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 IDENTIFICATION

A. Install labels complying with requirements for identification specified in IDENTIFICATION FOR ELECTRICAL SYSTEMS section and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.
SECTION 262816 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions, Instructions to Bidders, and Division 1 shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. This Section includes:

1. Enclosures
2. Fusible Switches
3. Molded Case Breakers
4. Non-fusible Switches
5. Shunt Trip Switches

1.3 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with adopted electrical code.

1. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code" shall be used.

B. Electrical Component Standards: Provide components complying with the adopted electrical code and which are listed and labeled by a NRTL. Comply with UL Standard 98, NEMA Standard KS 1 and Fed. Spec. WS-865C.

1.4 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
2. Altitude: Not exceeding 6600 feet.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 1 Specification Section and Basic Electrical Requirements Section.
B. Product Data: Submit manufacturer’s data including; ampere, voltages and current ratings, mounting requirements, physical dimensions and auxiliary components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. General Electric Co.
2. Square D Company.
4. Siemens, I.T.E.
5. Allen-Bradley Co.
6. Furnas Co.

2.2 DISCONNECT SWITCHES - GENERAL REQUIREMENTS

A. Provide disconnect switches of types, sizes and electrical characteristics indicated on drawings meeting the following criteria:

1. Rated 250 or 600 Volts (as appropriate for circuit).
2. 60Hz Frequency Rating.
3. Solid neutral, internally mounted.
4. Equipment Ground lug kit, internally mounted and labeled for copper or aluminum.
5. Quick-make, quick-break type.

B. Disconnects shall be constructed so that switch blades are visible in OFF position with door open.

C. Switch shall have a dual cover interlock to prevent unauthorized opening of the switch door when handle is in the "ON" position, and to prevent closing of the switch mechanism with the door open. The operating handle shall be an integral part of enclosure base whose position shall be easily recognizable and be lockable in the OFF position.

D. Current carrying parts shall be of high-conductivity copper, with silver-tungsten type switch contacts, and positive pressure type reinforced fuse clips.

E. Provide switch in proper enclosure as indicated or required. Install engraved plastic plate as to what each switch controls.

F. Where installed in hazardous locations disconnect shall be affixed with a proper NRTL label indicating that it may be installed in hazardous locations.
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ENCLOSED SWITCHES AND CIRCUIT BREAKERS

2.3 FUSIBLE SWITCHES

A. Shall meet all the Disconnect Switches - General Requirements.

B. Heavy-duty switches, with fuses of classes and current ratings indicated.
   1. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.

2.4 NON-FUSIBLE SWITCHES

A. Shall meet all the Disconnect Switches - General Requirements.

B. Heavy duty switches of classes and current ratings as indicated.

2.5 SINGLE MOLDED-CASE CIRCUIT BREAKER

A. The following applies to circuit breakers installed individually in an enclosure to protect a specific piece of equipment where a molded case breaker is identified on the plans. This section is not intended to set the circuit breaker requirements for those installed in panelboards, switchboards or switchgear. Refer to those equipment sections for circuit breaker requirements.

B. Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Provide factory-assembled, molded-case circuit breakers of frame size, poles and ampere ratings as indicated.

D. Construct with over center, trip-free, toggle type operating mechanisms with quick-make, quick-break action and positive handle indication.

E. Construct breakers for mounting and operating in any physical position and operating in an ambient temperature of 40°C.

F. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated. All breakers to be bolt-in type construction.

G. All breakers less than or equal to 600A shall be thermal-magnetic type with an inverse time-current element for overloads, and an instantaneous magnetic trip element for short circuits.
H. All breakers greater than 600A shall be electronic trip type with field adjustable settings for instantaneous trip, pickup levels, time adjustments and GFCI adjustments including time delay (where breakers are indicated on the plans to have GFCI protection). Breaker shall include an interchangeable rating plug that can be replaced in the field.

I. Breaker shall be installed in a proper NEMA rated enclosure.

1. NEMA 1 or better – Interior Locations.
2. NEMA 4X or better – Kitchen and areas of wash down.
3. NEMA 12 or better – Indoor locations subject to falling dirt and noncorrosive liquids.
4. NEMA 3R or better – Exterior Locations.

J. General Requirements:

1. Rated 250 or 600 Volts (as appropriate for circuit).
2. 60Hz Frequency Rating.
3. Solid neutral, internally mounted.
4. Equipment Ground lug kit, internally mounted and labeled for copper or aluminum

2.6 ACCESSORIES

A. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated.

B. Temperature Ratings: All conductor terminals and equipment enclosures to be NRTL Listed for use with minimum 75°C rated conductors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which electrical equipment is to be installed and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install disconnect switches, enclosed circuit breakers, VFDs and starters where indicated, complying with manufacturer’s written instructions, applicable requirements of NEC, NEMA, and NECA’S "Standard of Installation", and in accordance with recognized industry practices, and as follows:

1. Surface mount on walls or columns approximately 5'-0" to centerline above the floor where possible.
2. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
3. Provide engraved plastic nameplates on cover of each device identifying the loads connected.

B. Install disconnect switches, VFDs and starters used with motor-driven appliances, motors, and controllers within sight of controller position unless otherwise indicated.

C. Disconnect switches mounted on exterior HVAC equipment shall be caulked between switch and unit to provide weatherproof seal. Electrical Contractor to verify exact mounting location on unit so as not to cover up any removable panels.

D. Install all fuses in fused disconnects in the sizes and types as indicated on the plans and elsewhere in these specifications, after testing of the device has been completed as described in this specification section.

E. After installation of motor starter and motor, verify exact Full Load Current. Set the solid-state overload relay protection based on the F.L.A. of the motor.

3.3 GROUNDING

A. Provide equipment grounding connections for switches. Tighten connections to comply with tightening torques specified in UL Stds. 486A and B to assure permanent and effective grounds.

3.4 FIELD QUALITY CONTROL

A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION 262816
SECTION 262923 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 WORK INCLUDES
   A. Variable Frequency Drives

      1. 0 HP. thru 75 HP
      2. 75 HP. and larger

1.2 SUBMITTALS
   A. Submit in accordance with Division 1, Section 01340.
   B. Product Data:

      1. Submit manufacturer's data on variable frequency drive (VFD) systems, including descriptive literature, operating instructions, and maintenance and repair data, full size black line (24 X 36) indicating all power and control connections to the VFD Unit.
   C. Shop Drawings:

      1. Submit detailed shop drawings indicating information on load side filtering for line noise control, schematic and power and control connections for a complete system. Include all unit and enclosure dimensional data with shop drawings.
      2. Submit manufacturer's data on variable Frequency drive systems, including descriptive literature, operating instructions, wiring diagrams and maintenance and repair data.

1.3 SUMMARY
   A. Provide adjustable frequency drive system designed for continuous variable-torque (torque proportional to square speed) pump and fan duty as indicated on drawings; suitable for use on direct connected motors or motors connected by power transmission components, to pump or fan load.
   B. Coordination with the respective equipment suppliers regarding exact horsepower and control arrangements and shall furnish and install variable Frequency drives as required for a complete and properly operating system. Coordinate with the Division 23 Contractor for control requirements.

1.4 QUALITY ASSURANCE
   A. Manufacturer’s Qualifications: Firms regularly engaged in manufacturer of voltage source variable Frequency drives of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than ten (10) years.
   B. Codes and Standards:

      1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC.
      2. NEMA Compliance: Comply with applicable requirements of NEMA standards.
1.5 PRODUCTS

A. ACCEPTABLE MANUFACTURERS

1. Manufacturers: Subject to compliance with the Requirements, provide new Variable Frequency Drive Units (VSD) as manufactured by one of the following:
   a. Danfoss
   b. ABB

PART 2 - PRODUCTS

2.1 GENERAL

A. Adjustable Frequency drive system shall be designed for continuous variable-torque (torque proportional to square speed) fan duty; suitable for use on direct connected motors or motors connected by power transmission components, to fan loads.

B. Coordination with the respective equipment suppliers regarding exact fan horsepower and control arrangements and shall furnish and install VSDs as required for a complete and properly operating system.

C. Adjustable Frequency drive system shall be designed for continuous operation at 480 Volts, three phase and the feeder ampacity requirements shall not exceed that as indicated on the drawings.

2.2 VARIABLE FREQUENCY DRIVES 0 HP. THRU 75 HP

A. General:

1. Variable Frequency Drives (VFD) shall provide variable speed operation through the use of an adjustable frequency inverter system. The units shall be factory furnished and assembled, complete with all necessary controls, circuitry, and hardware as required to provide the functions herein specified, and shall only require field connections; from the 480 volt (nominal), 3-phase, 3-wire power source; from the control circuitry; from motor leads to load side of the variable frequency controller.

2. The VFDs shall be manufactured by reputable companies having no less than seven (7) years’ experience in VFD technology.

B. Basic Design:

1. Variable Frequency Power and Logic Unit shall be constructed using completely solid state components.

2. Unit shall transform 208 volts, 3 phase, 60 Hertz input power into frequency and voltage controlled 3 phase output power; suitable to provide positive speed and torque control to standard induction motors.

3. Output through a multistage process; the first stage shall convert the AC utility 480 volts, 3 phase, 60 Hertz input power to a filtered, fixed DC voltage through the use of a full wave diode bridge. This shall be done to provide a minimum input power factor of .95 throughout the speed range. Drives employing a phase controlled Silicon Controlled Rectifier (SCR) front end will not be acceptable.

4. The second stage shall convert the fixed voltage DC to an adjustable level of DC through the use of a transistorized chopper or Silicone-Controlled Rectifier. This stage may be eliminated by use of equipment using a sine-coded pulse width modulated inverter.

5. The third stage shall invert the adjustable level of filtered DC into a frequency and voltage controlled 3 phase adjustable AC output for speed control, through the use of
transistorized inverters, or gate-turn-off (GTO) devices. The variable frequency output of the inverters shall be accomplished by voltage source, current source, or sine-coded pulse width modulation schemes.

6. All stages of the VFD will not produce any electrical noise or harmonic distortion back onto the incoming AC power line that will cause any adverse effects to any electrical, electronic, digital, and electromechanical devices on the premises. Line filters or reactors shall be included and installed on each drive to eliminate any feed back onto the buildings AC electrical system.

7. Each unit shall include an internal contactor for across the line operation and transfer control circuitry for transferring operation from the inverter to the across the line operation at a constant speed. The contactor shall be located inside the variable speed controller cabinet and manual switch control shall be capable of transferring the motor power source from the variable speed controller to a bypass contactor located within the variable speed controller. The bypass system shall include safety circuitry to insure that no damage to the variable speed control device or the driven equipment will occur due to a change of operation. All normal control functions shall occur during both variable speed and bypass mode of operation.

C. Speed Control: Stepless throughout speed range under variable torque load on continuous basis.

D. Adjustable Frequency Control:
   1. Control shall be accomplished using a full wave diode bridge rectifier, fixed DC section, and with minimum .95 power factor.
   2. The VFD shall operate from 208V, 3-phase, 60Hz input power. Normal operation shall not be affected by variation in input voltage between 188V and 218V.
   3. The VFD shall be provided with Gate Turn Off (GTO) devices or transistors for high reliability in output power switching circuit.

E. Control Operating Ambient Temperature Range: 32° F. to 104° F.

F. Output Power:
   1. Output frequency does not vary with load; with any input frequency variations; with plus-or-minus 10% input voltage changes; or with temperature changes within ambient specification.
   2. Output frequency adjustable in proportion to any of following:
      a. 4-20 mA DC analog signal
      b. 0-5 VDC analog signal
      c. 0-10 VDC analog signal
   3. The VFD shall be inherently "soft starting" such that the motor will start at zero frequency and shall linearly ramp up to the setpoint frequency. Inrush current to the motor during starting, shall not exceed 115% of motor rated current. The VFD shall have built-in overload protection on each phase to the motor.
   4. The output shall maintain constant RMS volts per cycle within 3% of an output frequency covering a range of 3 to 60 Hz. Voltage in the three phases of the output shall be balanced within 1%. Equipment size and power output shall be sufficient for the motor to which it is connected.
   5. Variable Frequency Drive unit shall be furnished with rating not less than the motor nameplate rated full load running current.
6. Exact horsepower of the VFD shall be determined by the supplier of the VFD driven equipment.

G. Enclosure:
   1. Provide Variable Frequency Drive unit in a free-standing, NEMA-1/NEMA 3R panel enclosure fabricated of code gauge cold-rolled steel. The door shall be flanged, gasketed and mounted on semi-concealed pinion type hinges. The entire enclosure shall be primed and finished with industrial texture paint. The electrical bus shall be copper at all connection points. The enclosure will contain all the air circulating fans and air filters that are required for ventilation and to prevent enclosure over-temperature cutouts. No external fans, condensers or heat exchangers shall be required for cooling of the unit due to cabinet heat buildup. All components and controls that are integral to the VFD enclosure shall be completely factory installed and prewired with labeled cable terminals for field connections.

H. Provide controller with over-voltage clamp preventing damage by regenerated energy from high inertia loads or unstable motors.

I. Control includes following:
   1. Input reference clamp which prevents excessive reference signal from affecting control response.
   2. Automatic Control:
      a. The VFD shall accept a 4 - 20 mA signal supplied from a process variable transducer, a PLC Controller, or a local Direct Digital Control (DDC) panel. The VFD control system, when in the "AUTOMATIC" mode, shall energize the motor when the Building Control System closes the enable contacts on the VFD. The motor shall be started in a controlled mode and ramped up to the speed called for by the process variable.

      b. On a "STOP" command, the VFD will ramp the motor speed down under a controlled mode. The speed shall be infinitely varied between minimum speed and full rated speed either in direct proportion or inverse proportion to the signal from the process variable transducer, PLC Controller, or DDC panel in order to precisely match the application to the load. With nominal input power voltage and constant load, linearity and repeatability accuracy of the 3-phase outputs shall be within 1% of the process variable transducer's, PLC Controllers or DDC panel's control signal.

   3. Manual Control:
      a. The VFD shall be able to be operated in a manual mode that is independent of any process variable transducer, PLC Controller, or DDC control signal. In manual mode, the speed will be capable of being varied from 0 to 100% speed. This will be done from a control setting on the front panel as specified hereinafter. Manual control override shall not require any programming or interior modifications to VFD. Manual control shall be possible without stopping the drive, shutting down the system or modifying the unit operating parameters or reconfiguring system hardware.

   4. The VFD shall include the following adjustable control functions:
      a. Acceleration time adjustable from 1 to 60 sec
      b. Deceleration time adjustable from 1 to 60 sec (separate control from the acceleration time adjustment)
      c. Minimum motor speed adjustable from 0% to 100% of maximum motor RPM
      d. Maximum motor speed adjustable from 80% to 100% of maximum motor RPM
e. Output frequency range adjustable from 3 to 60 Hz
f. Motor current limit adjustable from 30% to full rated motor current

5. Operator's Control Panel:
   a. An operator’s control panel shall be mounted on each VFD compartment door and shall include the following devices in addition to any previously specified devices:
   b. POWER ON indicating light
c. VFD RUNNING indicating light
d. VFD SHUTDOWN ALARM indicating light
e. Audible alarm that will sound anytime the VFD is locked out of operation. This shall also include a set of dry isolated form C contacts for remote alarming by the owner.
f. ALARM SILENCER push-button switch
g. VFD POWER DISCONNECT switch with external interlock operating handle
h. EXTERNAL FUSIBLE DISCONNECT switch that will drop all incoming power to the VFD without interrupting any other piece of equipment that might be tied to the same power supply; each unit shall include one 3 pole, 600 volt, quick-make, quick-break, manually operated switch connected in series with one replaceable dual element rejection type fuse per switch pole.
i. START/STOP push-button mounted in unit enclosure door and with unit start/stop control circuitry factory arranged and wired for local start/stop. Labeled terminals shall be factory furnished and wired for remote control circuitry wiring connections as indicated in wiring diagrams on drawings.
j. MANUAL/AUTO SELECTOR switch
k. Manual speed control potentiometer with linear calibration. This is used when the MANUAL/AUTO mode selector switch is in the "Manual" mode.
l. Digital indicator with linear calibration in percent of motor rated RPM. The digital speed display shall not require the use of a tachometer generator.
m. Digital indicator calibrated for percent of motor rated load current in amps. The digital indicator may be same as used for the percent speed indicator, but a SELECTOR switch must then be provided.
n. Control cabinet locking handle.
o. Bypass selector switch for selection of the VFD operation of the operation of across the line starter.

J. Provide following self-protection equipment and reliability features in all controls:
1. Limit-to-limit output current to 150% or inverter rating.
   a. Current limit functions automatically preventing over-current trip due to momentary overload conditions; allowing inverter to continue operation.

2. Instantaneous over-current trip safely limits output current under 50 microseconds due to phase-to-phase short circuits or severe overload conditions, with shutdown as recommended by the equipment manufacturer.

3. Under-voltage trip protects inverter due to non-momentary power or phase loss, with shutdown as recommended by the equipment manufacturer.
   a. Under-voltage trip activates automatically when line voltage drops 15% below rated input voltage.
4. Over-voltage trip protects inverter due to voltage levels in excess of its rating, with shutdown as recommended by the equipment manufacturer.
   a. Over-voltage trip activates automatically when DC bus in controller exceeds 750 VDC.

5. Over-temperature trip protects inverter from elevated temperatures in excess of its rating.
   a. When over-temperature trip point is reached in any section of the enclosure or in any section of the electronics in the VFD unit, a cabinet over-temperature light shall be continuously illuminated.
   b. When over-temperature trip point is reached in the motor, a motor over-temperature light shall be continuously illuminated.

6. Automatic Reset/Restart:
   a. When trip condition results from under-voltage, over-voltage or over-temperature, it automatically resets and inverter automatically restarts upon removal or correction of causative condition.
   b. For safety and equipment protection, limit number of reset/restart attempts for to 3.
   c. When in 3 attempts reset/restart is not successful, inverter shuts down safely, requiring manual restart.
   d. When within 6 attempts successful reset/restart occurs, Auto Reset/Restart circuit reset attempts counted to 0 after approximately 2 minutes of continuous operation.

7. Short-Circuit Protection: In event of a phase-to-phase or phase-to-ground short circuit, control shuts down safely without component failure.

8. Power Interruption: When input or output power contactor is opened while control is activated, unit is not damaged.

9. Stand-Alone Operation: Provides for start-up, trouble-shooting, and operation of control without motor or any other equipment connected to inverter output.

10. START/STOP Control: Enables controller to be started or stopped by any of the following:
    a. Contact closure
    b. Use of motor starter or contactor in input power line
    c. Speed control signal dropping below or rising above minimum

11. Minimum and Maximum Speed Adjustment Potentiometers:
    a. Minimum speed adjustment potentiometer allows operating user to adjust minimum speed at which control will run motor from 0 to 25% when following 5000 ohm potentiometer.
    b. Maximum speed adjustment potentiometer allows adjustment of maximum speed, at which control will run motor from 80 to 100% when following 5000 ohm potentiometer

12. Isolation of current and voltage signals from logic circuitry.


14. Dual-Safety Shut-Downs:
a. In event of sustained power loss, control shut down safely without component failure; on return of power system automatically returns to normal operation, when start is ON without forced deceleration and or drive fault.

b. In event of momentary power loss; control shuts down safely without component failure; on return of power system automatically returns to normal operation, when start is ON.

c. An adjustable time delay relay shall be used for restart after power failure and to provide time delay on "start" after "stop" control circuitry has been activated to prevent damage to the fan, motor or variable frequency drive unit. Time delay relay shall be solid-state type with a minimum range adjustment to 2 minutes delay after energization. Set delay time as recommended by the variable frequency drive unit manufacturer.

15. The variable frequency drive shall be protected from being restarted into a motor coasting in either the forward or reverse direction to protect the components of the VFD.

16. The VFD shall be protected from power line voltage transients resulting from the following:
   a. Switching the primary of a line transformer
   b. Energization or de-energization of contactors, relays, and other power equipment from the power line
   c. Line-to-line or line-to-ground fault
   d. Lightning
   e. Notching from other VFDs or electronic switching power supply equipment

17. Solid state transient protection integral to the VFD shall be provided to a minimum of 10,000 volts and 50 joules without failure. The SCR’s transistors and diodes located in the converter and inverter sections of the VFD shall have a minimum peak inverse voltage rating of 1,500 volts. Surge withstand capability of power input, power output and control signal inputs and outputs shall meet or exceed American National Standards Institutes (ANSI) standard C37.90-19-8 and Institute of Electrical and Electronic Engineers (IEEE) standard 472-1974 without failure. Failure is to be defined as loss of components in the VFD including power semi-conductors, logic components and/or fuses.

2.3 ACCESSORIES

A. Door mounted interlocked disconnect switch

B. Motor thermal overload protection with reset

C. HAND/OFF/AUTO switch; door mounted, with manual speed control potentiometer
   1. Provide contacts for Building Control System can monitor position of HOA switch. (Reference drawings)

D. VFD/BYPASS switch; door mounted to allow operator to bypass controller and activate motor using bypass contacts.
   1. Provide contacts for Building Control System can monitor position of switch. (Reference drawings)

E. Smoke mode interface with terminal strips and manual speed potentiometers.

VARIABLE-FREQUENCY MOTOR CONTROLLERS 262923 - 7
PART 3 - EXECUTION

3.1 COORDINATION
A. Coordinate with Division 23 Contractor to ensure all power and control interlocks are provided and operational for complete operating system.
B. Provide electrical and control diagrams to affected contractors showing all interlocking wiring and control input locations.

3.2 INSTALLATION
A. The Contractor shall make installation as indicated on drawings and shall install wiring and make connections as indicted in wiring diagrams on contract drawings and in accordance with the manufacturer’s approved shop drawings.
B. After installations are completed, the Contractor shall provide the services of the variable frequency drive unit manufacturer’s service engineer for complete checkout, start-up, and adjustments for unit and to put unit into complete and proper operation. Units shall not be energized or operated until checkout and put into operation by the service engineer. The motor shall be energized and operated through the variable frequency drive.
C. CAUTION: DO NOT ENERGIZE THE VARIABLE FREQUENCY DRIVE UNITS WITHOUT LOAD CONNECTIONS TO MOTORS BECAUSE IT COULD CAUSE MAJOR DAMAGE TO THE VARIABLE FREQUENCY UNIT.
D. Electrical Connections:
   1. Ensure drive units are wired properly, with rotation in direction indicated, designed for proper fan performance.
   2. Provide positive electrical equipment and motor grounding as per the latest NEC and as recommended by the VFD manufacturer.
E. As-Built Drawings:
   1. The VFD unit manufacturer shall provide shop drawings for approval, which shall include complete description and specification data; complete wiring and connection diagrams for the units as furnished and as to be installed for this project, including control and power wiring as indicated in the wiring diagrams on the contract drawings; installation instruction; and instructions for operation, maintenance, servicing, and adjustments.

3.3 FIELD QUALITY CONTROL
A. After drive installation is complete, and after motor has been energized by factory trained technician, test each drive to demonstrate proper operation of unit at performance specifications.
B. When possible, field.correct malfunctioning units; then retest to demonstrate compliance.

3.4 START UP & SERVICE
A. Manufacturer shall provide factory-supervised start-up service for each drive specified.
B. Training:
   1. The VFD manufacturer shall provide complete on-site training for the Owners Operating, Maintenance, and Engineering personnel. This training shall be a
minimum of 2 days and shall include a complete description on the Theory of Operation, Operation Procedures, Functional and Operating Characteristics of Specific Logic Boards, Troubleshooting, Repair and Preventative Maintenance. A simulated failure is required to be diagnosed and repaired as part of this training.

C. Operations and Maintenance Manuals shall be provided and referenced during the instruction and training of the Owner’s personnel.

D. Guarantee:
   1. Each VFD unit shall be operated for a burn-in period of 100 hours minimum at the rated load and at the maximum ambient temperature in the unit manufacturer’s plant prior to shipment.
   2. The equipment shall be guaranteed free of defects and completely operational for a period of three (3) years from date of acceptance of equipment by the Owner. The guarantee shall be provided with two (2) years complete parts and labor coverage and one (1) year at 50% parts and labor coverage. The guarantee shall include all required labor including shipping and travel time.

END OF SECTION 262923
SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements as set forth in Division 26 COMMON WORK RESULTS FOR ELECTRICAL Section shall apply to Work of this Section.

1.2 SUMMARY

A. Section includes packaged engine generators suitable for use in mission critical applications, with the following features:

1. Gas engine.
2. Gas fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor engine generator enclosure.
8. Finishes.

B. Generator shall be used as a stand-by source for providing reliable power with no run-time limitations while the primary source is unavailable.

1.3 DEFINITIONS

A. 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.

1.4 QUALIFICATIONS

A. The Manufacturer/Supplier shall have an office that is staffed with trained mechanics for installing and servicing generators.

B. The Manufacturer/Supplier shall have available staff capable to provide all services for maintaining generator/alternators include all routine services as well and emergency repair.

C. The Manufacturer/Supplier shall have technicians fully capable of providing instruction and routine emergency maintenance service on all generator system components.

1.5 ACTION SUBMITTALS

A. Review of shop drawings does not relieve Contractor of responsibility for errors and omissions in shop drawings. Contractor is responsible for dimensions and sizes of equipment. Inform Consultant in writing of equipment differing from that specified.
B. 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 gallons per hour (liters per hour) at 0.8 power factor at 0.75 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute (cubic meters per minute) at 0.8 power factor, with air-supply temperature of 80 deg F. Provide Drawings indicating 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.

C. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
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. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.
7. List all deviations from Construction Documents and specifications with explanation.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Submit an organizational diagram indicating the key technical staff proposed for the project including, Project Manager, installers, etc.

C. 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.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
6. Report of exhaust emissions showing compliance with applicable regulations.
D. Field quality-control reports.

E. Warranty: Submit a list of all warranties and guarantees provided by the manufacturer. All parts and labor shall be warranted for 5-years from date accepted by Owner for building use and operation.

1. Provide an alternate cost for a warranty from year 2 through year 5 so that costs are clearly identified for extended warranty.
2. Warranty and service shall include a four (4) hour on site emergency response guarantee

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 260000 "Operation and Maintenance Data," 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.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency’s Field Supervisor: Certified by NETA to supervise on-site testing.

C. Code and Standards:

1. National Fire Protection Association (NFPA) Publications:
   a. No. 70: National Electrical Code (NEC)
   b. No. 37: Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
   c. No. 30: Flammable and Combustible Liquids Code
2. Underwriter's Laboratories, Inc. (UL) Publications:
   a. No. 508: Electric Industrial Control Equipment
   b. No. 50: Cabinets and Boxes
   c. No. 2200: Stationary Engine Generator Assemblies

3. National Electrical Manufacturers Association (NEMA) Publications:
   a. ICS: Industrial Control and Systems
   b. IS4: Terminal Blocks for Industrial Control Equipment
   c. II2: Electrical Indicating Instrument - Relay
   d. MG1: Motors and Generators
   e. MG2: Safety Standard for Construction and Guide for Selection
       Installation and use of Electric Motors and Generators.

4. American National Standards Institute (ANSI) Publications:

5. Engine Standards
   a. SAE 1349
   b. ISO 8528, Part 2
   c. EGSA 101P
   d. IEEE 446-1987 (Prime application)

D. Exhaust emission requirements
   1. Engine/Alternator set shall be in compliance with all applicable Air Pollution
      Control Laws, including any and all Federal, State and Local laws, EPA
      certifications, ordinances, guidelines and practices. Where subject to more
      than one emission law or standard, the more stringent law or standard shall apply.
   2. Provide all necessary permits and licenses for construction, installation and
      operation. These shall include all permits or licenses required by any local Air
      Quality Management District or commission. The permits and licenses shall cover
      the entire period of construction extending to acceptance and turn-up as well as
      the initial operational permits

1.10 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide generator of one of the following:
   1. Caterpillar
   2. Cummins
   3. Generac
   4. MTU

B. Source Limitations: Obtain packaged engine generators and auxiliary components from
   single source from single manufacturer.
C. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

D. 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 1500 feet.

2.2 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 qualified testing agency, and marked for intended location and use.

C. Power Rating: Stand-by

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. Service Load: 250 kVA. (200 KW).

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz.

H. Voltage: 480-V ac.

I. Phase: Three-phase, four wire, wye.

J. Induction Method: Turbocharged.

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 engine generator center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.

N. Engine Generator Performance:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
   a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.

3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. 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.

6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
   a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: 8 seconds.

2.3 DIESEL ENGINE

A. Fuel: ASTM D 975, diesel fuel oil, Grade 2-D S15.

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 set 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-, UV-, 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**: Commercial 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 12 dB at 500 Hz.
2. **Sound level measured** at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

G. **Air-Intake Filter**: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. **Starting System**: 24-V electric, with negative ground.

1. **Cranking Motor**: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
2. **Cranking Cycle**: 60 seconds.
3. **Battery**: Lead acid with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
4. **Battery Cable**: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
5. **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.
6. **Battery-Charging Alternator**: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
7. **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 to 140 deg F (minus 40 to 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.


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 and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel. Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Sized to run the generator for 24 hours at 75% load.
2. Tank level indicator.
4. Leak detection in interstitial space.
5. Vandal-resistant fill cap.
7. Tank shall be equipped with an additional 1” drain line with a “X” fitting on both sides of the tank.
2.5 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: Remote-control contacts in the transfer switch initiate starting and stopping of engine generator.

B. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:

E. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. 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.
3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:
   a. Cranking control equipment.
   c. Control switch not in automatic position alarm.
   d. Overcrank alarm.
   e. Overcrank shutdown device.
   f. Low-water temperature alarm.
   g. High engine temperature pre-alarm.
   h. High engine temperature.
   i. High engine temperature shutdown device.
   j. Overspeed alarm.
   k. Overspeed shutdown device.
   l. Low fuel main tank.
   1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article.
   m. Coolant low-level alarm.
   n. Coolant low-level shutdown device.
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o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. Battery high-voltage alarm.
t. Low cranking voltage alarm.
u. Battery-charger malfunction alarm.
v. Battery low-voltage alarm.
w. Lamp test.
x. Contacts for local and remote common alarm.
y. Low-starting air pressure alarm.
z. Low-starting hydraulic pressure alarm.
aa. Remote manual stop shutdown device.
bb. Air shutdown damper alarm when used.
cc. Air shutdown damper shutdown device when used.
dd. Generator overcurrent-protective-device not-closed alarm.
e. Hours of operation.
ff. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via ModBus and Ethernet. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

G. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

H. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
12. Air shutdown damper when used.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Generator overcurrent-protective-device not-closed alarm.

I. 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.

J. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

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 engine generator 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 engine generator 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.
2.7 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 12-lead alternator.

E. Range: Provide broad 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: Dripproof.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
   2. Maintain voltage within 15 percent on one step, full load.
   3. Provide anti-hunt provision to stabilize voltage.
   4. Maintain frequency within 5 percent and stabilize at rated frequency within 5 seconds.

I. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

J. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing. 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.

B. Hinged Doors: With padlocking provisions.

C. Muffler Location: External to enclosure.

D. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
   1. Louvers: Fixed-engine, cooling-air inlet and discharge.
   2. Automatic Dampers: At engine cooling-air inlet and discharge.
2.9 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.

   2. Shore A Scale Durometer Rating: As recommended by manufacturer.
   3. Number of Layers: As recommended by manufacturer.

B. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

C. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.10 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 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.


PART 3 - EXECUTION

3.1 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.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions.
C. Equipment Mounting:
   1. Install packaged engine generators on cast-in-place concrete equipment bases.
   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.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
   1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
   2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
   3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."

F. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

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

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "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.

G. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
3.5 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. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

C. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

D. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Remove and replace malfunctioning units and retest as specified above.

G. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

H. 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.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

J. Load Bank Testing: Perform a 100% load bank test on the new generator for 1 hour. After 1 hour reduce to 75% for 1 hour and then 50% for 1 hour. Record event readings and provide a final report.

3.6 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include
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routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

3.7 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 263213
SECTION 263600 – TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements as set forth in Division 26 COMMON WORK RESULTS FOR ELECTRICAL Section shall apply to Work of this Section.

1.2 DESCRIPTION OF WORK

A. Drawings and schedules indicate extent of fuses required.

B. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Bypass/isolation switches.
2. Remote annunciator system.
3. Remote annunciator and control system

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section

B. Product Data: Submit manufacturer’s data on operational and electrical characteristics and accessories. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches. Also submit a single-line diagram showing connections between transfer switch, bypass/isolation switch, power sources, and load; interlocking provisions for each combined transfer switch and bypass/isolation switch; interconnection wiring between transfer switches, bypass/isolation switches, annunciators and control panels.

1.4 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of transfer switches, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer: Qualified with at least 5 years of successful installation experience on projects with electrical installation work similar to that required for project.

C. Comply with adopted electrical code requirements as applicable to construction and installation of overcurrent protective devices.

D. Compliance: Devices shall be Listed and Labeled by a qualified testing agency and marked for the devices intended purpose and application.
1.5 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: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products of one of the following (for each type and rating of overcurrent protective device):

1. ASCO
2. Russ-Electric

2.2 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 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

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. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for [three] [30] <Insert number> 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 non-fused, 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. Surge Protective Device: Service rated.
   7. Service Disconnecting Means: Externally operated, manual electrically actuated

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Neutral Terminal: Solid and fully rated unless otherwise indicated.

M. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

N. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

O. Enclosures: General-purpose NEMA 250, [Type 1] complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

P. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable shrinkable sleeve markers at terminations.
   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.

2.3 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
   2. Switch Action: Double throw; mechanically held in both directions.
   3. 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.
   4. Conductor Connectors: Suitable for use with conductor material and sizes.
   6. Main and Neutral Lugs: Compression type
   7. Ground Lugs and Bus-Configured Terminators: Compression type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Initiation occurs without active control of generator.
   b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
   c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Under-voltage 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.
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: Instantaneous; shall initiate shutdown sequence 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 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.

G. 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. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. 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.

2.4 NONAUTOMATIC TRANSFER SWITCHES

A. Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

B. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
C. Pilot Lights: Indicate source to which load is connected.

   1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

E. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

F. 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.
   3. Conductor Connectors: Suitable for use with conductor material and sizes.
   5. Main and Neutral Lugs: Compression type
   7. Ground bar.
   8. Connectors shall be marked for conductor size and type according to UL 1008

2.5 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:
   1. Source Limitations: Same manufacturer as transfer switch in which installed.
   2. Comply with requirements for Level 1 equipment according to NFPA 110.
   3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
      a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
      b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
      c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
      d. Transition: Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
      e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
      f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
      g. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting:
   1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in other sections.
   2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
   3. Provide workspace and clearances required by NFPA 70.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1

3.2 CONNECTIONS

A. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer’s limitations on bending radii.

C. Ground equipment according to specifications and adopted electrical code.

D. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections [with the assistance of a factory-authorized service representative]:
   1. 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. Perform visual and mechanical inspection of surge arresters.
l. 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. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
c. Verify settings and operation of control devices.
d. Calibrate and set all relays and timers.
e. Verify phase rotation, phasing, and synchronized operation.
f. Perform automatic transfer tests.
g. 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. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance /

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation
5. 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. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. 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


   D. Coordinate tests with tests of generator and run them concurrently.
   E. 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.
   F. Transfer switches will be considered defective if they do not pass tests and inspections.
   G. Remove and replace malfunctioning units and retest as specified above.
   H. Prepare test and inspection reports.
   I. 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. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

END OF SECTION 263600
SECTION 264313 – SURGE PROTECTION DEVICES (SPD)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. The specifications in this section describe the electrical and mechanical requirements for a protection system provided by high-energy transient voltage surge suppressors. The specified system shall provide effective, high-energy surge current diversion and be suitable for application in ANSI/IEEE C62.41 Category A, B and C environments (as tested by ANSI/IEEE C62).

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 Specification Section and GENERAL ELECTRICAL REQUIREMENTS Section.

B. Product Data: Provide catalog sheets showing voltage, physical size, IEEE let through voltage for each waveform listed, UL1449 latest revision, latest edition, suppressed voltage ratings, dimensions showing construction, lifting and support points, enclosure details, per mode and per phase peak surge current, modes of discrete suppression circuitry, warranty period and replacement terms, conductor size, conductor type and lead length.

C. Submit product data for all components and accessories.

D. Manufacturer’s Installation Instructions: 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 product. Indicate maximum size of circuit breaker or fuse to be connected for each unit.

E. List and detail all protection systems such as fuses, disconnecting means and protective features.

F. Provide verification that the TVSS device complies with the required UL1449 latest edition, latest revision, and CSA approvals.

G. Provide actual let through voltage test data in the form of oscillograph results for the ANSI/IEEE C62.41 Category B/C (combination wave) and A1 (ringwave) tested in accordance with ANSI/IEEE C62.45.
H. Provide spectrum analysis of each unit based on MIL-STD-220A test procedures between 10 kHz and 100 kHz verifying the devices noise attenuation equals or exceeds 40 dB at 100 kHz.

I. For retrofit mounting applications, provide electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

J. Provide test report from a recognized independent testing laboratory verifying the suppressor components can survive published surge current rating on a per mode basis using the IEEE C 62.41, 8x20 microsecond current wave. Test data must be on a complete SPD with internal fusing in place. Test data on an individual module is not acceptable.

1.4 QUALITY ASSURANCE

A. The specified system shall be designed, manufactured, tested and installed in compliance with the following codes and standards:

1. Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, C62.45)
2. American National Standards Institute
3. Federal Information Processing Standards Publication 94 (FIPS PUB 94)
4. National Electrical Manufacturer Association
5. National Fire Protection Association (NFPA 70, 75 and 780)
6. Where an electrical code is not adopted the latest edition of NFPA 70 "National Electrical Code" shall be used.
7. MIL Standard 220A Method of Insertion Loss Measurement
9. Underwriters Laboratories UL 1283/UL 60384-14 and UL 1449 (most recent edition)
10. Canadian Standards (cUL or cETL)
11. RoHS compliant.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. The operating temperature range shall be -40° to 70° C (-40° to 160° F).
2. The unit shall be capable of operation up to 13,000 feet above sea level.
3. No appreciable magnetic fields shall be generated.

1.6 WARRANTY

A. The following warranty requirements shall be in addition to, and run concurrently with other warranty requirements provided in project Contract Documents:

1. Minimum Requirements:
2. 20 Years Unlimited Replacement Warranty on all parallel-wired surge protective devices ( SPD). Additionally, the warranty shall state that during the applicable warranty period any SPD which fails due to any transient surge activity, including lightning, shall be repaired or replaced by the manufacturer without charge.
3. Warranty shall be for purchaser, building owner or end user and shall not be dependent on specific purchase entity for unit.

4. In the event the SPD is destroyed, there shall be full replacement of damaged or failed suppressor. Pro-rating is not allowed.

5. No exclusions from transient surge events (i.e. lightning strike, arcing fault on system, facility or utility transients). Gross negligence is excluded (i.e. removing system neutral to ground bond, Hi-Pot testing with SPDs on-line, etc.).

6. Since “Acts of Nature” or similar statements typically include the threat of lightning to which the SPDs shall be exposed, any such clause limiting warranty responsibility in the general conditions of this specification shall not apply to this particular section. That is, the warranty must specifically provide for unlimited free replacements of the SPD in the event of failure caused by the effects of lightning and all other electrical anomalies. The warranty shall cover the entire device, not just various components, such as modules only.

7. Provide electrically operated equipment specified in this Section that is listed and labeled. As defined in the National Electrical Code, Article 100, Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” as defined in OSHA Regulation 1910.7.

1.7 MANUFACTURER QUALIFICATIONS

A. The SPD’s shall be manufactured in the USA by a manufacturer that has been regularly engaged in the design, manufacturing and testing of SPD’s of the types and ratings required for a period of not less than five years. Manufacturers requesting product approval must meet or exceed the written specification contained herein.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide panelboard products of one of the following (for each type and rating of panelboard and enclosure)

1. Advanced Protection Technologies
2. Current Technology (Thomas/Betts)
3. LEA International
4. MCG Surge Protection
5. Total Protection Solutions

2.2 PERFORMANCE

B. General

1. The SPD shall be listed by ETL, UL, or other nationally recognized test laboratory to UL’s 1283 and UL’s 1449 standards (latest edition, latest revision), and not merely the components or modules. All SPD’s shall be Type 1 for use in Type 1 and Type 2 locations. All SPD units shall to RoHS compliant.
2. The SPD shall protect all modes L-G, L-N, L-L, and N-G, for WYE systems have discrete suppression circuitry in L-G, L-N and N-G, and have bi-directional, positive and negative impulse protection. Line-to-neutral-to-ground protection is not acceptable where line-to-ground is specified, and accordingly reduced mode units with suppression circuitry built into only 4 modes are not acceptable. For delta systems, the unit shall have discrete suppression circuitry in L-G and L-L.

3. The maximum continuous operating voltage (MCOV) of all components shall not be less than 125% for a 120V system and 120% for 220 and 240V systems, and 115% for 277 and 480V systems.

4. All SPD’s shall be equipped with a comprehensive monitoring system which shall include a visual LCD panel display providing information on unit status and phase loss/protection loss.

5. No unit will be accepted as an “approved equal” unless it meets the warranty, strength, safety features, IEEE let-through levels, modes of discrete suppression circuitry, fusing, independent third party per mode surge testing, and all other requirements of this specification.

6. If a disconnect switch is specified, the disconnect switch and the SPD as a system shall be capable of interrupting up to a 200kA symmetrical fault current with 600 VAC applied.

7. Each design configuration shall have the maximum single pulse surge current capacity per mode verified through testing at an independent, nationally recognized test laboratory.

   a. To be considered for approval, the manufacturer must submit a test report on a unit which was tested with internal over current fusing in place. The test shall include a 1.2 X 50 μsec 6000V open circuit voltage waveform and an 8 X 20 μsec 500A short circuit current waveform to benchmark the unit’s suppression voltage, followed by a single pulse surge of maximum rated surge current magnitude with an approximated 8 X 20 μsec waveform. To complete the test, another identical surge shall be applied to verify the unit’s survival. Compliance is achieved if the suppression voltage found from the two impulses do not vary by more than +10%. Test data on an individual module is not acceptable.

8. SPD shall be separate from panelboard.

C. SERVICE ENTRANCE PROTECTION

1. The SPD for this location shall be as indicated on project drawings.

2. Medium to High Exposure: Service entrance panels shall be protected by a Total Protection Solutions panel mounted SPD, model TK-ST300-3Y480-L for 277/480 wye (4W+G) volt panels.

3. The manufacturer shall provide written specifications showing let-through voltage of the unit with six inches of lead length (at the module or at the lug data is not acceptable as it does not represent true "as installed" performance) pursuant to ANSI/IEEE C62.41 and C62.45, 2002, categories B/C and C-High bi-wave, 90 degree phase angle, positive polarity, measurements in peak voltage from the zero reference, all dynamic tests except N-G, and UL suppressed voltage ratings, all of which shall be no higher than:
### ANSI/IEEE C62.41-2002 Measured Limiting Voltage

#### B/C Impulse (6kV, 3kA)

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>277/480 (3Y480)</td>
<td>1075V</td>
<td>1077V</td>
<td>1718V</td>
<td>1073V</td>
</tr>
</tbody>
</table>

#### C-High Impulse (20kV, 10kA)

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>277/480 (3Y480)</td>
<td>1475V</td>
<td>1825V</td>
<td>2270V</td>
<td>1670V</td>
</tr>
</tbody>
</table>

#### UL Voltage Protection Ratings

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>277/480 (3Y480)</td>
<td>1200V</td>
<td>1200V</td>
<td>1800V</td>
<td>1200V</td>
</tr>
</tbody>
</table>
D. The unit shall have a peak surge current of no less than 240kA/phase, 120kA/mode, 8 X 20 us waveform, single impulse, independently verified.

E. Internal Fusing - Overcurrent Protection

1. Each Metal Oxide Varistor, or other primary suppression component, shall be individually fused for safety and performance to allow the SPD to withstand the full rated single pulse peak surge capacity per mode without the operation or failure of the fuses. Overcurrent fusing that limits the listed peak surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode overcurrent fusing is not acceptable where there is more than one MOV per mode.
2. Fusing shall be present in every mode, including Neutral-to-Ground.
3. The fusing shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied.

F. The SPD shall be marked with a Short Circuit Current Rating (SCCR) and shall not be installed at a point on the system where the available fault current is in excess of that rating per the National Electric Code.

G. The suppressor shall include Form C dry contacts (N.O. or N.C.) for remote monitoring capability and shall have at minimum a NEMA 4 steel enclosure.

H. The SPD shall have an internal audible alarm with mute on front cover.

I. SPD’s for service entrance locations shall have a transient event counter with LCD panel display and reset button on the front cover.

J. SUBPANEL and LIGHTING PANEL PROTECTION

1. SPD(s) for this location shall be as indicated on project drawings. SPD’s shall be certified to UL 60384-14 (formerly UL1283), and UL1449 Fourth Ed. Type 1 or 2 for use in Type 1 and Type 2 locations. All SPD units shall be RoHS compliant.

K. Subpanels and lighting panels shall be protected by a Total Protection Solutions panel mounted SPD, model TK-LP120-3Y277/480-L-F for 277/480 (4W+G) volt panels, TK-LP120-3Y208-L-F for 120/208 (4W+G) volt panels:

L. The manufacturer shall provide written specifications showing let-through voltage of the unit with six inches of lead length (at the module or at the lug data is not acceptable as it does not represent true "as installed" performance) pursuant to ANSI/IEEE C62.41 and C62.45, 1991, categories A1 & A3 ring wave, 180 degree phase angle, category B3 Ringwave, and UL suppressed voltage ratings, 90 degree phase angle, positive polarity, measurements in peak voltage from the zero reference, all dynamic tests except N-G, which shall be no higher than:
### ANSI/IEEE C62.41-1991 Measured Limiting Voltage

#### A1 Ring Wave (2kV, 67A) Tested at 180 degree phase angle

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
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<tbody>
<tr>
<td>120/208 (3Y208)</td>
<td>29V</td>
<td>46V</td>
<td>39V</td>
<td>40V</td>
</tr>
<tr>
<td>277/480 (3Y480)</td>
<td>34V</td>
<td>54V</td>
<td>40V</td>
<td>40V</td>
</tr>
</tbody>
</table>

#### A3 Ring Wave (6kV, 200A) Tested at 180 degree phase angle

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
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<tbody>
<tr>
<td>120/208 (3Y208)</td>
<td>56V</td>
<td>81V</td>
<td>88V</td>
<td>112V</td>
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<tr>
<td>277/480 (3Y480)</td>
<td>71V</td>
<td>119V</td>
<td>73V</td>
<td>67V</td>
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</table>

#### B3 Ring Wave (6kV, 500A) Tested at 90 degree phase angle

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<tr>
<th>Voltage (Voltage Code)</th>
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<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
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<tbody>
<tr>
<td>120/208 (3Y208)</td>
<td>437V</td>
<td>592V</td>
<td>612V</td>
<td>324V</td>
</tr>
<tr>
<td>277/480 (3Y480)</td>
<td>670V</td>
<td>785V</td>
<td>1020V</td>
<td>324V</td>
</tr>
</tbody>
</table>

### UL Voltage Protection Ratings

<table>
<thead>
<tr>
<th>Voltage (Voltage Code)</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/208 (3Y208)</td>
<td>700V</td>
<td>700V</td>
<td>1000V</td>
<td>700V</td>
</tr>
<tr>
<td>277/480 (3Y480)</td>
<td>1200V</td>
<td>1200V</td>
<td>2000V</td>
<td>1200V</td>
</tr>
</tbody>
</table>

M. The unit shall have a peak surge current of no less than 120kA/phase, 8 X 20 us waveform, single impulse, verified by third party test reports.
N. Internal Fusing - Overcurrent Protection

1. Each Metal Oxide Varistor, or other primary suppression component, shall be individually fused for safety and performance to allow the SPD to withstand the full rated single pulse peak surge capacity per mode without the operation or failure of the fuses. Overcurrent fusing that limits the listed peak surge current of the SPD is not acceptable. Replaceable cartridge type per phase or per mode overcurrent fusing is not acceptable where there is more than one MOV per mode.

2. Fusing shall be present in every mode, including Neutral-to-Ground.

3. The fusing shall be capable of interrupting up to a 200kA symmetrical fault current with 600VAC applied.

4. The SPD shall be marked with a Short Circuit Current Rating (SCCR) and shall not be installed at a point on the system where the available fault current is in excess of that rating per the National Electric Code Article 285.

O. The SPD shall be capable of attenuating internally generated ringing type transients and noise and shall have an enhanced transient filter supported by a specification sheet which lists the IEEE A1 Ring Wavelet- through levels no higher than those set forth above.

P. Because of space limitation, the enclosure shall not exceed 4.0” D x 4.0” W x 10.3” H to allow close-to-the load installation on flush mount panels and between adjacent panelboard. For recessed panels, a flush mount cover plate shall be provided with each unit.

Q. The suppressor shall include Form C dry contacts (N.O. or N.C.) for remote monitoring capability and shall have at minimum a Nema 1 steel enclosure.

R. The SPD shall have an internal audible alarm with mute on front cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the SPDs with the conductors as short and straight as practically possible. Where installed in conduit, the conduit shall be PVC.

B. Follow the SPD manufacturer’s recommended installation practice as outlined in the equipment installation manual. The electrical contractor shall ensure that all neutral conductors are bonded to the system ground at the service entrance or the serving isolation transformer prior to installation of the associated SPD.

C. Main service entrance SPDs shall be installed on 60 to 100 amp dedicated breakers, or, where indicated, shall be installed on a non-fused disconnect switch provided by manufacturer of the SPD or provided by the Contractor, that meets or exceeds the fault current rating of the switchgear.
D. Distribution panel and motor control center units shall be installed on 60-amp dedicated circuit breakers, or, where indicated, shall be wired directly to the main lugs or feed through lugs, or wired directly to the bus bars.

E. Branch panel SPDs fed from step-down transformers or located downstream of distribution panels shall be installed on 30-amp dedicated circuit breakers, or, where indicated, shall be wired directly to the main lugs or feed through lugs, or wired directly to the bus bars.

F. The installing contractor shall comply with all applicable codes.

END OF SECTION 264313
SECTION 265100 – INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Interior lighting fixtures, lamps, and ballasts.
   2. Emergency lighting units.
   3. Exit signs.
   4. Lighting fixture supports.

B. See Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

C. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of interior lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer’s Qualifications: Firms with at least three (3) years of successful installation experience on projects with interior lighting fixture work similar to that required for this project.

C. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 220, 410, and 510 as applicable to installation, and construction of interior building lighting fixtures.

D. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No.’s LE 1 and LE 2 pertaining to lighting equipment.

E. UL Compliance: Comply with UL standards, including UL 486A and B, pertaining to interior lighting fixtures. Provide interior lighting fixtures and components which are UL-listed and labeled.

F. Work in this division shall include all lighting fixtures as specified and as called for in the Electrical Scope of Work and shall also include lamps as required installed in fixtures. Lighting fixtures shall be complete including hickeys, suspension nipples, connectors and all other material and equipment as required for re-hanging fixtures in accordance with the National Electrical Code. Fixtures and lamps shall be wiped clean before and after installation.

G. LED fixtures shall comply with UL 1598 and UL 8750.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis-of-Design Product: The design for each lighting fixture is based on the product named in the schedule. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified in the schedule.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS
A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
B. Metal Parts: Free of burrs and sharp corners and edges.
C. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
D. 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.
E. 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.
   4. Laminated Silver Metallized Film: 90 percent.
F. Plastic Diffusers, Covers, and Globes:
   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      a. Lens Thickness: At least 0.125 inch minimum unless different thickness is indicated.
      b. UV stabilized.
   2. Glass: Annealed crystal glass, unless otherwise indicated.
G. Any flat acrylic lens specified in fluorescent fixtures shall be a minimum of .125" thick, KSH type K12, or approved equal, unless otherwise shown in schedule on fixtures.
H. Fixtures shall be wired with color coded fixture wire approved for temperature involved. Circuitry wiring run in fluorescent fixture channels shall be "THHN" or "XHHW" and not less than #12 AWG.

2.3 EXIT LIGHTS
A. Illumination source shall be Light EMITTING Diodes (LED's). Provide automatic transfer circuit to transfer to battery source on loss of AC source.
B. Exit lights furnished with 6" high stencil letters. Use letter coloring as defined in light fixture schedule.
2.4 DRIVERS

A. LED Drivers shall be electronic type, labeled as compliant with radio frequency interference (RFI) requirements of FCC Title 47 Part 15, and comply with NEMA SSL 1 “Electronic Drivers for LED Devices, Arrays, or Systems”. LED drivers shall have a sound rating of “A”, have a minimum efficiency of 85%, and be rated for a THD of less than 20 percent at all input voltages.

B. Ballasts and drivers shall be rated for the ambient temperatures in which they are located.

C. All drivers shall be for operating at 120 or 277 volts as required. Contractor shall verify voltage prior to submission of shop drawings.

2.5 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type rated for automatic 90-minute operation minimum.

2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power supply circuit voltage fails. 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.

4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Battery-backed LED emergency lighting fixtures shall consist of a normal LED fixture with some or all of the LEDs connected to a battery or charger. The battery shall be nickel cadmium and sized for a minimum of 90 minutes of fixture operation. The charger shall be solid-state and provide overload, short circuit, brownout and low battery voltage protection. The battery and charger shall include self-diagnostic and self-exercising circuitry to exercise and test itself for 5 minutes every month and for 30 minutes every 6 months. The fixture shall include a test/monitor module with LED status indicating lights mounted to be visible to the public. The fixture shall not contain an audible alarm.

B. Acceptable Battery Manufacturers

1. Bodine

2. IOTA

3. As specified in light fixture schedule

2.6 LAMPS

A. LM80 rated fixtures only. LED diodes shall have a CRI minimum of 82 and CCT (correlated color temperature) of 4000K unless indicated differently on light fixture schedule. Rated LED lamp life shall be 50,000 hours minimum. Driver shall be internal to LED fixtures and have a nominal operating voltage of 120Vac to 277Vac.
2.7 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 0.5-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two (2), 0.5-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.


E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

F. Rod Hangers: 0.1875-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture. Contractor shall coordinate fixture mounting with architectural ceiling type to verify compatibility.

B. Comply with NFPA 70 and NEC section 410 for minimum fixture supports.

C. Suspended Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Hand indirect light fixture by use of aircraft cable unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. 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 265100.
SECTION 265300 – EMERGENCY LIGHTING FIXTURES

PART 1 - GENERAL

1.1 INCLUDES
A. This Section includes emergency light sets, exit fixtures with integral emergency battery backup, and emergency LED fixture power supplies with integral battery backup.
B. Related Sections: The following Section contain requirements that relate to this Section:
   1. Division 26 Section "Interior Lighting Fixtures" for regular fixtures that may be connected to emergency circuits to provide emergency lighting.

1.2 SUBMITTALS
A. General:
   1. Submittals shall be made on all items in this section and shall be in accordance with the General Conditions.
B. Product Data: Submit manufacturer’s technical product data, independent testing lab photometric data, including fixture specifications and installation instructions, for each type of emergency unit required. Include data substantiating that materials comply with requirements.
C. Maintenance Data: Submit maintenance data and parts lists for each type of emergency unit installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the General Conditions of this Specification.
D. Samples of specific individual products for approval where indicated.

1.3 PREREQUISITE CONDITIONS
A. The General Conditions, Supplemental General Conditions and Special Conditions are part of this contract and requirements set forth in those sections apply to all work in this division of the specifications.

PART 2 - PRODUCTS

2.1 EMERGENCY LIGHTING FIXTURES
A. Quality Assurance
   1. Manufacturer's Qualifications: Firms regularly engaged in manufacture of interior lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years. All units specified in this section of the specifications hereinafter shall be furnished with not less than a five (5) year prorated warranty and not less than one year full replacement.
   2. Installer's Qualifications: Firms with at least three (3) years of successful installation experience on projects with interior lighting fixture work similar to that required for this project.
   3. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
   4. UL Compliance: Emergency lighting fixtures shall be UL listed and labeled.

6. Local Code Compliance: Comply with applicable local codes and regulations for emergency lighting and exit signage including, but not limited to, colors and letter heights for exit signs.

B. Deliver products in factory containers; store in clean, dry space in original container. Protect products from fumes and construction traffic.

C. Furnish stock of replacement lamps amounting to 15 percent (but not less than one lamp in each case) of each type and size lamp used in each type unit.

D. The following features apply to designer series type emergency light sets:
   1. Self-contained emergency lighting units with style, shape, and trim as indicated.
   2. Battery: Sealed, maintenance-free, lead-acid type with 10 year nominal life.
   3. Charger: Minimum two-rate, fully automatic, solid-state type, with sealed transfer relay.
   4. Operation: Relay turns lamp on automatically when supply circuit voltage drops to 80 percent of nominal or below. Lamp operates for duration of outage, up to 1.5 hours. Lamp automatically disconnected from battery of voltage approaches deep-discharge level. When normal voltage is restored, battery is automatically recharged within 16 hours and then floated on trickle charge.
   5. Control panel contains low-voltage disconnect switch, LED indicator light, voltmeter, test switch, and concealed terminals for remote lamp head connection.
   6. Cylinder Style: Lamp, battery, charger, and relay mounted in cylindrical housing. Unit shall have the following features:
      a. Cylinder shall be mounted on metal base with locking swivel joint providing 180 deg, 2-way lamp aiming.
      b. Shallow profile base shall mount on wall or ceiling.
      c. Finish: Matte white for exposed parts, or as selected by the Architect.
   7. Recessed or Semi-recessed Type with Lens: Wall or ceiling mounted with the following features:
      a. Lamps and reflectors as indicated.
      b. Finish: Matte white for exposed parts, or as selected by the Architect.
      c. Trim at wall or ceiling conceals fixture opening.
      d. Lens: 0.125-inch thick prismatic acrylic.
   8. Surface-Mounted Type with Lens: Wall or ceiling-mounted unit with the following features:
      a. Lamps and reflectors as indicated.
      b. Finish: Matte white for exposed parts or as selected by the Architect.
      c. Lens: 0.125-inch thick prismatic acrylic.

E. The following features apply to Die Cast Self-contained, a.c. battery-illuminated exit sign unit, universal mounting with downlight.
   1. Lamps: Manufacturer’s standard, furnished with unit.
   2. Style, shape, trim, material, finish, and arrangement of housing as indicated.
3. Faceplate: Aluminum stencil face with red high-impact, UL 94 V-O rated, plastic letters and snap out arrows.
4. Mounting provisions shall suit individual installation conditions.
5. Battery: Sealed, maintenance-free, lead-acid type, with 10-year nominal life.
6. Charger: Minimum 2-rate, fully automatic, solid-state type, with sealed transfer relay.
7. Finish: Matte white for exposed parts, or as selected by the Architect.
8. Operation: Sign is illuminated by a.c. powered lamps under normal conditions. Relay turns emergency lamps on automatically when supply circuit voltage drops to 80 percent of nominal or below. Lamps operate for duration of outage, up to 1.5 hours. Lamps automatically disconnect from battery when voltage approaches deep-discharge value. When normal voltage is restored, a.c. powered lamps are relighted and d.c. lamps are switched off. Battery is automatically recharged within 16 hours and maintained on trickle charge.

F. The following features apply to internal type inverter units for designated LED fixtures, provided under Division 26 Section "Interior Lighting" provide internal self-contained, modular, battery-inverter unit, factory mounted within the fixture body.

1. Description: Self-contained units complying with UL 924.
2. Battery: Sealed, maintenance-free, lead-acid type rated for automatic 90 minute operation minimum.
3. Charger: Fully automatic, solid-state type with sealed transfer relay.
4. Operation: Relay automatically turns lamp on when power supply circuit voltage fails. 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.
5. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
6. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
7. Battery-backed LED emergency lighting fixtures shall consist of a normal LED fixture with some or all of the LEDs connected to a battery or charger. The battery shall be nickel cadmium and sized for a minimum of 90 minutes of fixture operation. The charger shall be solid-state and provide overload, short circuit, brownout and low battery voltage protection. The battery and charger shall include self-diagnostic and self-exercising circuitry to exercise and test itself for 5 minutes every month and for 30 minutes every 6 months. The fixture shall include a test/monitor module with LED status indicating lights mounted so as to be visible to the public. The fixture shall not contain an audible alarm.

G. Acceptable Battery Manufacturers

1. Bodine
2. IOTA
3. As specified in light fixture schedule
2.2 INSTALLATION

A. Setting and Securing: Set units plumb, square, and level with ceiling and walls and secure in accordance with manufacturer’s written instructions and approved shop drawings. Conform to the requirements of NFPA 70.

B. Mounting heights specified or indicated are to bottom of fixture for suspended or ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures.

C. Recessed and semi-recessed fixtures may be supported from suspended ceiling support system if the ceiling system support rods or wires are installed at a minimum of four rods or wires per fixture and located not more than 6 inches from fixture corners. For fixtures smaller than the ceiling grid, install a minimum of four rods or wires per fixture and locate at corner of the ceiling grid in which the fixture is located. Do not support fixtures by ceiling acoustical panels. Where fixtures smaller than the ceiling grid are indicated to be centered in the acoustical panel, support fixtures independently with at least two 3/4-inch metal channels spanning and secured to the ceiling tees. Rods or wires for lighting fixture supports shall conform to the requirements of Section "Acoustical Treatment." Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.

D. Lamping and Connection: Lamp units in accordance with manufacturer’s instructions. Make external wiring connections required for proper functioning.

E. Coordinate with other electrical installations as appropriate for proper installation of emergency lighting fixtures.

F. Clean emergency units light set upon completion of installation.

G. Adjust aimable fixtures to provide light intensities in egress paths.

H. Ground non-current-carrying parts of equipment; where the copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

I. Tighten grounding connections to comply with tightening torques specified in UL Standard 486A.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Tests: After emergency lighting units have been installed and building circuits have been energized with normal power source, apply and interrupt electrical energy to demonstrate proper operation. Remove and replace malfunctioning units with new units and proceed with retesting. Give the Architect advance notice of dates and times for all field tests. Provide instruments as required to make positive observation of test results. Include the following in tests:

1. Duration of supply
2. Low battery voltage shutdown
3. Normal transfer to battery source and re-transfer to normal
4. Low supply voltage transfer

B. Insulation Resistance Test: Perform as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables" both before and after connection of fixtures and equipment.
C. Electrical Continuity Tests: Perform as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables".

D. Lamp Replacement: Prior to tests, install new lamps in emergency lighting units. After testing, place malfunctioning lamps.

END OF SECTION 265300
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SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Exterior luminaires with lamps and ballasts.
   2. Luminaire-mounted photoelectric relays.
   3. Poles and accessories.
   4. Luminaire lowering devices.

B. Related Sections include the following:
   1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color rendering index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 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.

B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4.

C. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.

D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

   1. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h).
1.5 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. Photoelectric relays.
3. Lamps, including life, output, and energy-efficiency data.
5. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
6. Anchor bolts for poles.
7. Manufactured pole foundations.

1.6 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. 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 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: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
3. Basis of Design Product: The design of each item of exterior luminaire and its support is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

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.

B. Retain first paragraph below if some lighting units or luminaires are indicated to have Type I, II, III, IV, or V distribution pattern in "Requirements for Individual Exterior Lighting Devices" Article or in Exterior Lighting Device Schedule or details on Drawings.

C. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

F. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

G. 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.

H. Exposed Hardware Material: Stainless steel.
I. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

J. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

K. 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.

L. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

M. 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.

N. 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 per light fixture schedule.


   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
   3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
   4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
      a. Color: as shown on drawings.
2.3 LUMINAIRE-MOUNTED PHOTORELAYS

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.
   1. Relay with locking-type receptacle shall comply with NEMA C136.10.
   2. Adjustable window slide for adjusting on-off set points.

2.4 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
   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 Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
   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 stainless-steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.5 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); 1-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
1. **Shape:** Round, straight.
2. **Mounting Provisions:** Butt flange for bolted mounting on foundation or breakaway support.

**B. Steel Mast Arms:** Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.

**C. Brackets for Luminaires:** Detachable, cantilever, without underbrace.

1. Adapter fitting welded to pole and bracket, 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.

**D. Pole-Top Tenons:** Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

**E. Intermediate Handhole and Cable Support:** Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

**F. Grounding and Bonding Lugs:** Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "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.

**G. 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.

**H. Platform for Lamp and Ballast Servicing:** Factory fabricated of steel with finish matching that of pole.

**I. Prime-Coat Finish:** Manufacturer's standard prime-coat finish ready for field painting.

**J. Galvanized Finish:** After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

**K. 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 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 per light fixture schedule.
2.6 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

2.7 REQUIREMENTS FOR INDIVIDUAL EXTERIOR LIGHTING DEVICES

A. Exterior Lighting Device Type:

1. Basis-of-Design Product: <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

2. [Available ]Manufacturers:
   a. <Insert, in separate subparagraphs, manufacturer's name.>

3. Voltage: [120] [277] [480]-V ac.


5. Lamps: <Insert quantity and description if not indicated elsewhere.>


8. Lens: <Describe types, materials, and features not indicated elsewhere.>


11. IESNA Lateral Distribution Class: [I] [II] [III] [IV] [V].

12. IESNA Cutoff Category: [Cutoff] [Semicutoff] [Noncutoff].


15. Photometric Performance of Installed Units:
   a. Spot Intensity: Minimum initial [horizontal] [vertical] illumination [at grade] [on subject being illuminated] shall be <Insert fc (lx)> at a point <Insert location of test point>.
   b. Average Intensity: Minimum average initial [horizontal] [vertical] illumination [at grade in the illuminated area] [on subject being illuminated] shall be <Insert fc (lx)>.
   c. Uniformity: For a spacing between adjacent fixtures in parallel rows of <Insert spacing distance>, fixture to fixture and row to row, the maximum-to-minimum initial [horizontal] [vertical] point illumination between any pair of adjacent lighting units, including those in parallel rows, shall be not greater than <Insert ratio>.
   d. Cutoff: Maximum initial [horizontal] [vertical] illumination shall not exceed <Insert fc (lx)> at a point <Insert location of test point>.


18. Pole Description:
   a. Material or Type: [Steel] [Aluminum] [Fiberglass] [Decorative] [Laminated wood] [Wood] [Prestressed concrete].
   b. Luminaire Support Components and Accessories: [Mast arms] [Metal pole bracket] [Pole-top tenons] [Steps] [Intermediate handhole and cable support] [Grounding and bonding lug] [Cable support grip] <Insert option>.
   c. Mounting Provisions: [Concrete foundation] [Screw foundation] [Embedded].
   d. Luminaire Mounting Height above Finished Grade: <Insert dimension.>
PART 3 - EXECUTION

3.1 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.

3.2 POLE INSTALLATION

A. 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: 10 feet (3 m).
   3. Trees: 15 feet (5 m)

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 Section "Cast-in-Place Concrete."

D. 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.

E. Raise and set poles using web fabric slings (not chain or cable).

F. 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.

G. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.3 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "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.
B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundations.

3.4 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.

3.5 DEMONSTRATION

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

END OF SECTION 265600
SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals: Product Data.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized-steel sheet.

D. Sleeve Seals: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

2. Pressure Plates: Stainless steel. Include two for each sealing element.

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

2.2 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 GENERAL COMMUNICATION EQUIPMENT INSTALLATION REQUIREMENTS

A. Install communication equipment to allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

B. Install communication equipment to provide for ease of disconnecting the equipment with minimum interference to other installations.

C. Install communication equipment to allow right of way for piping and conduit installed at required slope.

D. Install communication equipment to ensure that connecting pathways and cables are clear of obstructions and of the working and access space of other equipment.
E. Install required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

F. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Comply with requirements in Division 08 Section "Access Doors and Frames."

G. Install sleeve and sleeve seals of type and number required for sealing communication service penetrations of exterior walls.

3.2 SLEEVE AND SLEEVE-SEALS INSTALLATION

A. 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.

B. Cut sleeves to length for mounting flush with both wall surfaces.

C. Extend sleeves installed in floors 2 inches above finished floor level.

D. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

E. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

F. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

G. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

H. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

I. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.3 FIRESTOPPING

A. Apply firestopping to communications penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Comply with requirements in Division 07 Section "Penetration Firestopping."

END OF SECTION 270500
SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals: Product Data and Shop Drawings.

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.


E. Coordinate layout and installation of telecommunications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. 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 for fastening cable ties to brackets.

B. Cable Trays: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing.

   1. Basket Cable Trays: 6 inches wide and 2 inches. Wire mesh spacing shall not exceed 2 by 4 inches
   2. Trough Cable Trays: 6-inch width.

C. Conduit and Boxes: Comply with Division 26 Section "Common Work Results for Electrical."

   1. Minimum Outlet Box Size: 2 inches wide, 3 inches high, 2-1/2 inches deep.

D. Backboards: 3/4 inch, 48 by 96 inches, fire-retardant-treated plywood.

2.2 GROUNDING

A. Comply with requirements in Division 26 Section "Common Work Results for Electrical" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.3 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

3.1 ENTRANCE FACILITIES
   A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and housing when so directed by service provider.
      1. Install underground entrance pathway, complying with Division 26 Section "Common Work Results for Electrical."

3.2 INSTALLATION
   A. Comply with NECA 1.
   B. Comply with BICSI TDMM for layout, and installation of communications equipment rooms.
   C. Cable Trays: Comply with the requirements in 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.

3.3 FIRESTOPPING
   A. Comply with requirements in Division 07 Section "Penetration Firestopping."
   C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING
   A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
   B. Comply with ANSI-J-STD-607-A.

3.5 IDENTIFICATION
   A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A.

END OF SECTION 271100
SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLEING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Performance Requirements: Comply with transmission standards in TIA/EIA-568-B.1.
B. Submittals: Product Data and Shop Drawings.
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.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
B. Cable Trays: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing.
   1. Basket Cable Trays: size indicated on drawings. Wire mesh spacing shall not exceed 2 by 4 inches.
   2. Trough Cable Trays: Nominally 6-inch width.
C. Conduit and Boxes: Comply with Division 26 Section "Common Work Results for Electrical."
   1. Minimum Outlet Box Size: 2 inches wide, 3 inches high, 2-1/2 inches deep.
D. Backboards: 3/4 inch, 48 by 96 inches, fire-retardant-treated plywood.

2.2 UTP CABLE

A. Description: 100 ohm, four-pair UTP, 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.
   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 or MPP, complying with NFPA 262.
      b. Communications, Limited Purpose: Type CMX: or MPP, CMP, MPR, MP, MPG, CM, or CMG.
2.3 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.

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 Panel: 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 indicated [conductor group of indicated cables, plus spares and blank positions adequate to satisfy 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, four-pairs in 36-inch 48-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.

2.4 TELECOMMUNICATION OUTLET/CONNECTORS


B. Workstation Outlets: Two port-connector assemblies mounted in single faceplate.
   1. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices."
   2. Metal Faceplate: Stainless steel, complying with requirements in Division 26 Section "Wiring Devices."
   3. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.
      a. Flush mounting jacks, positioning the cord at a 45-degree angle.
2.5 GROUNDING

A. Comply with requirements in Division 27 Section "Common Work Results for Communications" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.6 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA 606-A, and shall meet UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 WIRING METHODS


1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Division 26 Section "Common Work Results for Electricals."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.2 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."

C. Comply with requirements for installation of conduits and wireways specified in Division 26 Section "Common Work Results for Electrical."

D. 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.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
7. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

C. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

3.4 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with ANSI-J-STD-607-A.
C. Bond metallic equipment to the ground bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Comply with TIA/EIA-606-A.
1. Administration Class: 2.
2. Color-code, cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Labels shall be preprinted or computer-printed type with printing area and type color that is contrasting with cable jacket color, but still complying with TIA/EIA-606-A.

END OF SECTION 271500
CABLE TRAY

SECTION 272500 – CABLE TRAY

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Installations of cable tray systems for all work in Division 27 including required fittings and supports.

B. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, tests and services to install complete cable tray systems as shown on the drawings.

C. Cable tray systems are defined to include, but are not limited to straight sections of basket type cable trays, bends, tees, elbows, drop-outs, supports and accessories.

1.2 SUBMITTALS:

A. Submit complete shop drawings in accordance with Division 1 and Section 260500 Electrical Submittals.

B. Provide complete cable tray layout with shop drawings showing all fittings, expansion joints, fire stops, etc.

C. Cable trays for power feeders and instrumentation and auxiliary systems

1.3 STANDARDS:

A. UL approved as equipment grounding conductor

B. ANSI/NFPA 70 - National Electrical Code

C. ASTM A123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip

D. ASTM A653 - Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality

E. ASTM A1011 - Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High Strength Low Alloy with Improved Formability (Formerly ASTM A570 & A607)

F. ASTM A1008 – Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability (Formerly ASTM A611)

G. ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel

H. NEMA VE 1-1998 - Metallic Cable Tray Systems

I. NEMA VE 2-2000 - Cable Tray Installation Guidelines
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with these specifications, wire basket cable tray to be installed shall be as manufactured by Cooper B-Line, Inc.

B. Equal by Cablofil, Flexray,

2.2 WIRE BASKET SECTIONS AND COMPONENTS

A. General: Provide wire basket of types and sizes indicated; with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

B. Materials and Finishes: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A 510, Grade 1008 and shall be electro-plated zinc in accordance with ASTM B633, Type III, SC-1.

2.3 TYPE OF WIRE BASKET SUPPORT SYSTEM

A. All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be kinked and T-welded on all tray sizes.

B. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4 inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.

C. Wire basket sizes shall conform to the following nominal criteria:

1. Straight sections shall be furnished in standard 118 inch lengths.
2. Wire diameter shall be 0.196” (5mm) minimum on all mesh sections (minimum size of 4.5mm on stainless steel).
3. Wire basket shall have a 4 inch usable loading depth by 1 1/8 inches wide.

D. All fittings shall be field formed, from straight sections, in accordance with manufacturer’s instructions.

E. All splicing assemblies shall be UL/CSA approved as an Equipment Ground Conductor (EGC). Bond cable tray to ground at spacings not to exceed 100’ with a #6 AWG green insulated copper grounding conductor and listed terminations.

F. Wire basket supports shall be center support hangers, trapeze hangers or wall brackets as manufactured by Cooper B-Line, Inc.

G. Trapeze hangers or center support hangers shall be supported by 1/4 inch or 3/8 inch diameter rods.

H. Special accessories shall be furnished as required to protect, support and install a wire basket support system.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cable trays as indicated: Installation shall be in accordance with equipment manufacturer's instructions, and with recognized industry practices to ensure that cable tray equipment comply with requirements of NEC and applicable portions of NFPA 70B. Reference NEMA-VE2 for general cable tray installation guidelines.

B. Coordinate cable tray with other electrical work as necessary to properly integrate installation of cable tray work with other work.

C. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.

D. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE-2 guidelines, or in accordance with manufacturer's instructions.

E. Suspend horizontal runs of cable tray utilizing ½" diameter steel hanger rods and Unistrut P-1000 channel. Provide clips for attachment of side rail flange to each hanger. Provide hangers maximum 6'-0" on center. Each hanger designed for 500 pounds safe load. Use approved Beam clamps or bolted anchors. Anchors in concrete rated 1000 pounds safe load.

F. Cable tray installed so all parts of system are accessible for cable installation, inspection, and maintenance.

G. Provide hangers each side of expansion joint fittings within 24". Provide ground strap #3/0 copper across both rails of tray for ground continuity.

H. Install power cable in tray to maintain minimum one (1) cable diameter (of largest cable) space between cables to allow free air ampacity of cable per N.E.C. Tie cable to tray rungs with nylon ties, T&B "Tyrap" or equal. Use large ties. Tie cable at alternate rungs.

I. Identify cable in cable tray 20' O.C. with tags to indicate feeder designation and destination. Reference Section 16195.

J. Where cable trays penetrate fire rated walls, floors, etc., provide 16 gage steel sleeve through wall or floor sized to provide 2" clear space around tray. After cables are installed, firestop opening in accordance with fire stopping details provided by contractor/vendor installing firestop materials. Reference Section 16010.

   1. Provide 16 gage steel plates on both sides of opening to cover sleeve fastened to structure with minim of six (6) 1/2" bolts and inserts.
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SECTION 283100 – FIRE ALARM SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division – 1 Specification Sections, apply to work specified in this section.

1.02 GENERAL DESCRIPTION OF WORK

The Contractor shall layout, install, program, and test all equipment, devices and components for the fire alarm system for Readiness Center addition. The system shall be a Simplex 4100 ES, configured for mass notification.

The fire alarm system layout and installation shall include but not be limited to the following work:

1. Provide and install an addressable Fire Alarm Control Panel (FACP), configured for mass notification and connection to the base fiber network.
2. Provide and install an Annunciator.
3. Provide and install addressable manual fire alarm boxes at stairwells, building exits and other locations as shown on the drawings.
4. Provide and install addressable smoke detectors where shown on the drawings.
5. Provide and install carbon monoxide detectors where shown on the drawings.
6. Supervise sprinkler system workflow and supervisory devices provided under SECTION 211300.
7. Provide and install notification appliances throughout the building.
8. Provide and install new raceway and wire as required for all circuitry external to the panel.
   Provide and install interconnecting and control circuits.
9. Provide maintenance and testing of the new and existing fire alarm systems starting at the notice to proceed.

Details concerning all work required for the project follow in the specifications and are shown on the Contract Drawings.

1.03 CONTRACT DRAWINGS

The Fire Alarm Arrangement drawings included with these specifications are utilized to illustrate the general locations of the major components of the fire alarm system.

The Contractor’s Arrangement and Schematic drawings are required to show the detailed circuit
arrangements, in compliance with the riser diagrams, detailed to the specific equipment provided.

The drawings are as follows:

- **FA110**: FIRE ALARM ARRANGEMENT – PARTIAL FIRST FLOOR PLAN – AREA A
- **FA111**: FIRE ALARM ARRANGEMENT – PARTIAL FIRST FLOOR PLAN – AREA B
- **FA120**: FIRE ALARM ARRANGEMENT – SECOND FLOOR PLAN
- **FA200**: FIRE ALARM RISER DIAGRAM

See Paragraph 1.09 (System Arrangement and Design) for information regarding supplemental drawings.

### 1.04 Code Requirements

Fire alarm system layout, materials, manufacture, examination, testing, inspection, stamping, certifications, and documentation shall conform to applicable portions of the following adopted codes and standards, and all addenda thereto.

**UNIFIED FACILITIES CRITERIA (UFC)**

- **UFC 3-600-01**: FIRE PROTECTION ENGINEERING FOR FACILITIES (2018)
- **UFC 4-021-01**: DESIGN AND O&M: MASS NOTIFICATION SYSTEMS (2010)

**NATIONAL FIRE PROTECTION ASSOCIATION**

- **No. 70**: National Electrical Code (2017)
- **No. 72**: National Fire Alarm Code (2019)
- **No. 90A**: Installation of Air Conditioning and Ventilation Systems (2018)
- **No. 720**: Installation of Carbon Monoxide (CO) Detection and Warning Equipment (2015)

**AMERICAN NATIONAL STANDARDS INSTITUTE**


These specifications are based upon the latest national standards and codes in force at the time of issue. Any conflict between the referenced standards above shall be referred to the Engineer who will determine which standard shall govern. The Owner shall be the Authority Having Jurisdiction (AHJ) over interpretation of the Codes, Standards or laws referenced above. All correspondence requiring decision by the AHJ shall be directed through the Engineer for resolution. The requirements of these specifications and associated drawings take precedence over the minimum requirements of the Codes and Standards listed above.

### 1.05 Listings and Approvals

All equipment, devices and appliances furnished under these specifications shall be Factory Mutual (FM)
approved or Underwriters Laboratories (UL) listed, unless specifically noted otherwise. Approved or Listed equipment shall be so noted in the latest edition of the FM Approval Guide (P7825a) or the UL Fire Protection Equipment Directory.

1.06 CONTRACTOR'S QUALIFICATIONS

This section covers the technical qualifications required for the Contractor's Technical and Installation personnel. Proposed personnel shall be subject to the Owner's approval.

1.06.1 Contractor

Installation shall be performed by a Fire Alarm Contractor who is experienced in the layout and installation of fire alarm systems (minimum five years). Additionally, the Contractor shall have successfully installed fire alarm systems of the same type and layout as specified herein. The Contractor shall submit, with the bid, the names and locations of at least two installations where the Contractor installed such systems. The Contractor shall certify that each system has performed satisfactorily for a period of not less than two years.

1.06.2 Technician

Detailed layout shall be by a NICET Level III or IV Technician (Fire Alarm Systems Subfield of Fire Protection Engineering Technology), Registered Fire Protection Engineer, or a Registered Professional Engineer with at least two years of experience in fire protection layout.

1.06.3 Installation Supervisor

The Contractor's installation supervisor(s) shall have at least five years of experience in fire alarm installation, be technically competent, trained, and experienced in the installation and operation of the equipment under their jurisdiction, and authorized by the equipment manufacturer to perform the work stipulated. The supervisor shall be on the job site during the entire installation.

1.07 DOCUMENT SUBMITTALS

Document submittals shall be in accordance with SECTION 013304 and this section.

The Contractor shall submit the documents electronically, for review, to the Engineer prior to the start of fabrication or installation. The Contractor shall upload the submittal to the Engineer. The submittal shall include required information for all work included in this section. Documents shall be fully completed and certified by the Contractor as to the compliance of the information contained thereon with the requirements of the contract documents. Incomplete submittals will not be reviewed. Complete submittals will be reviewed by the Engineer and processed as specified in Division 1. The Engineer's review will be for general conformity to the specified requirements and is not intended to constitute detailed review or approval of content. Documents stamped ACCEPTED do not relieve the Contractor from any contract requirements.

All drawings shall be prepared in Revit 2019 or AutoCAD (Version 2010 or later). Drawings and data shall be in sufficient detail to indicate the kind, size, arrangement, and operation of component devices; the
external connections, anchorages, and supports required; and dimensions needed for installation and correlation with other equipment. All drawings shall be to a standard architectural scale which shall be noted on the drawings (Graphic Representation). Drawing size shall not be less than 30 inches by 42 inches or greater than 34 inches by 44 inches.

All Equipment and Material Data Sheets and Calculations shall be submitted as a single PDF document. The document shall include bookmarks for each product submittal. Drawings shall be submitted as individual full-size PDF files. A separate transmittal PDF file shall be included. The drawings and calculations shall have a certifications sheet bearing the seal of the registered professional engineer or the NICET Designer Certification. The transmittal shall also include the specification title, the specification number, and the Contractor’s name.

1.07.1 Documents Required

The following documents shall be submitted for this project.

1.07.1.1 Equipment and Material Data Sheets

Equipment and material data sheets shall be submitted for all equipment and devices used in the systems. If options are listed on the data sheets, the specific option for the project shall be clearly marked. The data sheet submittal shall include but not be limited to the following:

1. Fire Alarm Panels and Components – Documents shall include product data sheets, installation instructions and programming manuals.
2. Annunciator Panel and Components – Documents shall include product data sheets, installation instructions and programming manuals.
3. Distributed Power Supply Panel(s) and Components – Documents shall include product data sheets, installation instructions and programming manuals.
4. Batteries and Enclosures
5. Notification Appliances (Data sheets and installation instructions)
6. Initiating Devices (Data sheets and installation instructions)
7. Filters or Surge Suppression Devices (Data sheets and installation instructions)
8. Other field devices such as addressable interfaces, etc. (Data sheets and installation instructions)
9. Wire (including color code schedule)
10. Conductor Markers
11. Conduit and Supports
12. Conduit fill schedule. The schedule shall identify the diameters of all wire chosen, and the number of conductors allowed in each conduit size.
13. Junction Box Labels
14. Firestopping Materials and Systems
15. Terminal Strips and Connectors (Where Specifically Approved)

1.07.1.2 Arrangement Drawings

Arrangement drawings showing all fire alarm zone boundaries, shall be submitted showing the exact location of all equipment including, but not limited to, the following:
1. Fire Alarm Panels and Enclosures
2. Distributed Power Supplies and Amplifiers
3. Initiating Devices
4. Notification Appliances
5. Relays
6. Raceway
7. Annunciators
8. Addressable Interfaces and Control Modules
9. Noise Suppressors or Filters
10. Filters or Surge Suppression Devices

Raceway layout shall be shown on the drawings for all circuitry associated with the fire alarm system. This includes the 120-volt ac circuitry to the panel. Identification of all circuits within conduit shall be provided.

The arrangement drawings shall include scaled elevation details of the wall with the fire alarm panel and battery enclosure, distributed power supply LOCs and Annunciator. Where items noted are installed as part of a fire alarm panel assembly, the components may be shown only on the panel outline drawings.

Interconnection diagrams shall be submitted, showing the details of field wiring terminations on all devices, appliances and other field components. Interconnection diagrams shall be provided for all building interfaced equipment including but not limited to elevators, air handlers, dampers and security systems.

1.07.1.3 Schematic Drawings

Schematic type drawings shall be submitted that show all external circuits associated with the fire alarm system. Drawings shall show the arrangement of all devices on each circuit. Circuit and device numbers shall be chosen to correlate with the specific panel layout and programming including general contract requirements.

1.07.1.4 Fire Alarm System Panel Documents

These requirements apply to Fire Alarm Control Panel, Distributed Power Supply Panel, LOC panels and their associated circuitry. The following documents shall be submitted for each panel. Separate drawings are not required for each item listed below; however, the documents shall include all required information.

1.07.1.4.1 Outline Drawings. Drawings shall be submitted of the each panel showing the dimensions and arrangement of all lights, switches, and labels. Information shall be provided such as weight, mounting details, and wording of all labels. A second drawing shall be provided to show the arrangement of all circuit boards and modules in the panel.

1.07.1.4.2 Logic Diagrams. Logic diagrams shall be submitted that show complete operation of all alarm and control functions of the panels. A well written sequence of operations document or matrix may be substituted for these.
1.07.1.4.3 **Interconnection Diagrams.** Interconnection diagrams shall be submitted which show all external connections required for complete operation of the system as specified. Circuit numbers shall be shown on all connections to the terminal blocks and shall correlate with other drawings.

1.07.1.4.4 **Calculations.** The following calculations shall be submitted for each panel.

1.07.1.4.4.1 **Battery Calculations.** Battery calculations shall be submitted. If standard manufacturer’s forms are used, the manufacturer’s instructions shall also be included.

1.07.1.4.4.2 **Power Supply and Amplifier Calculations.** Calculations shall be provided for each power supply and amplifier to confirm the spare loading capacity requirements of these specifications are met. Calculations shall include the manufacturer’s listed rating for each piece of equipment.

1.07.1.4.4.3 **Power Supply and Amplifier Output Circuit Capacity Calculations.** Calculations shall be provided for each notification appliance circuit, both non-audio and audio, to confirm the circuit spare capacity requirements of these specifications are met. Calculations shall include the manufacturer’s individual output circuit rating for each power supply and amplifier.

1.07.1.4.4.4 **Circuit Sizing Calculations.** Calculations shall be provided for each external initiating, signaling line, notification (including audio) and control circuit to prove that wire sizes chosen have voltage losses or dB losses and current draws within the acceptable limits as stated by the manufacturer. Manufacturer data indicating maximum acceptable current draw and voltage loss or dB loss shall be included with calculations.

1.07.1.4.5 **Voice Message.** The panel manufacturer’s available voice messages shall be submitted on CD (standard Windows Media Player format) or cassette tape. The Engineer will choose the acceptable message for this facility.

1.07.1.4.6 **Textual Messages.** The Contractor shall submit the messages that will appear on the LCD Panel Display for each point monitored. The documents shall include a description of what areas of the text are not subject to modification, what choices are available for particular areas and what areas are custom text. Messages shall meet the requirements of Part 2 of these specifications.

1.07.1.5 **Annunciator Panel Documents**

1.07.1.5.1 **Outline Drawings.** Drawings shall be submitted of the panel showing the
dimensions and arrangement of all lights, switches, and labels. Information shall be provided such as weight, mounting details, and wording of all labels. A second drawing shall be provided to show the arrangement of all circuit boards and modules in the panel.

1.07.1.5.2 **Interconnection Diagrams.** Interconnection diagrams shall be submitted which show all external connections required for complete operation of the system as specified. Circuit numbers shall be shown on all connections to the terminal blocks and shall correlate with other drawings.

1.07.1.5.3 **Calculations.** If the annunciator has an independent power supply, calculations shall be provided to support battery sizing.

1.07.1.6 **Certifications**

1.07.1.6.1 The certification from the major equipment (control panel) manufacturer indicating that the Contractor is an authorized representative of the major equipment manufacturer. Include name and address in the certification. The Contractor shall also provide certification from the manufacturer for the proposed supervisor of installation.

1.07.1.6.2 The record of completion as required by NFPA 72. The form shall be filled in as described in the standard. All information shall be typewritten. Provide the preliminary copy after completion of all pre-tests but before the final test. Provide the final copy after the completion of the final acceptance tests.

1.07.1.7 **Testing Forms**

Later.

1.07.2 **Document Disposition**

1.07.2.1 The reviewed documents will be returned, in one of the following ways:

1. ACCEPTED
2. ACCEPTED WITH COMMENTS NOTED
3. ACCEPTED WITH COMMENTS NOTED - RESUBMITTAL REQUIRED
4. REJECTED

1.07.2.2 When the documents are returned marked ACCEPTED, the Contractor is released to begin fabrication and installation.

1.07.2.3 When the documents are returned marked ACCEPTED WITH COMMENTS NOTED, the Contractor shall make the noted changes and is released to begin fabrication and installation. The changes do not need to be resubmitted until the Record markups (red-lines) are submitted, unless noted otherwise.

1.07.2.4 When the documents are returned ACCEPTED WITH COMMENTS NOTED – RESUBMITTAL REQUIRED, the basic layout is approved, however, the Contractor is
not released to fabricate or begin installation. A complete resubmittal is required (all documents) unless specifically noted otherwise. All revisions shall be backcircled. The Contractor’s Engineer’s seal or NICET Certification is required on the resubmittal unless specifically noted otherwise.

1.07.2.5 When the documents are returned REJECTED, the Contractor shall revise the layout and calculations based on the review comments and resubmit. All revisions shall be backcircled. The NICET Certification or Contractor’s Engineer’s seal is required on the resubmittal.

1.07.2.6 Resubmittals will not be reviewed without a correction or response for each review comment (backcircled).

1.08 FINAL DOCUMENTATION

The Installation, Operation and Maintenance manual shall be submitted for review with the red line drawings. Final copies of the Installation, Operation and Maintenance Manual (with all drawings) are required within three (3) weeks after the final acceptance test.

Marked up shop drawings (red-lines) and final copies of drawings shall be submitted. Red-lines shall be submitted prior to the acceptance test. Record Drawings are required to be submitted to the Engineer within two weeks after the acceptance test.

All submittals shall be electronic, in the form and arrangement of the original document submittals. After acceptance of all documents, one hard copy shall be distributed to the Owner (drawings shall be rolled). A CD or DVD shall accompany the hard copy. The electronic copy shall include a single PDF file of the Installation, Operational and Maintenance Manual. Drawings shall be included as individual full-size PDF files and individual bound Revit or AutoCAD files. A copy of the CD or DVD shall be forwarded to the Engineer.

The following documents shall be included in the final documentation.

1.08.1 Installation, Operations and Maintenance Manual

A complete Installation, Operations and Maintenance Manual (with all drawings) shall be furnished for the Fire Alarm System. The hard copy of the manual shall be assembled and bound in a durable binder per SECTION 013304 requirements. The manuals shall be permanently labeled with at least the project name, project number and date of completion. The following items shall be included in the manual as necessary:

1. Table of Contents.
2. Index tabs for each section.
3. Contractor’s name, address, telephone number, 24-hour emergency number and manager’s name.
4. Description of the equipment (Equipment data sheets for all panel components, initiating devices, notification appliances and all other components of the system (see specific requirements below).
5. Each panel’s manufacturer, model number, revision, serial number.
6. Model numbers and revision numbers for each component of the panel(s).
7. Revision dates of all software, firmware or chips required to be updated for panel updates.
8. Installation instructions for each component of the panel, each device, each appliance, and each other component of the fire alarm system.
9. Complete and detailed operating instructions including philosophy of operation. Generic panel instruction manuals are not acceptable unless marked up to address the specific configuration and features of the panel at this facility.
10. Maintenance instructions for each component of the panel, each device, each appliance, and each other component of the fire alarm system.
11. Programming Manuals for all programmable components of the system.
12. Programming key and/or passwords to allow complete programming of the system.
13. The panel’s printout of programming.
14. Acceptance test data – Measured current draw data, battery voltages, etc. from the acceptance test.
15. Record of Completion.
16. Certifications (See specific requirements below).
17. Recommended test methods, test frequencies, visual inspection frequencies.
18. List of maintenance tools furnished with the equipment.
19. Record Drawings (See specific requirements below).
20. Calculations (See specific requirements below).

The above listed requirements are a minimum. Additional information, which is necessary for proper operation and care of the equipment, shall be included. Requirements which are clearly not applicable to the equipment may be deleted.

1.08.2 Record Drawings

The record drawings shall be prepared in Revit AutoCAD. Record drawings and calculations shall be certified by the NICET Technician or sealed by the Contractor’s Professional Engineer.

The record drawings shall include all required shop drawings noted in Paragraph 1.07. The information on the shop drawings shall be modified to show the final condition of the fire alarm system. Modifications shall include, but not be limited to, the following items:

1. All devices and appliances and other components shall be shown in their actual locations. Device numbers shall be updated where necessary to show final conditions. Notations regarding re-use or relocation of devices or appliances shall be removed.
2. Conduit routing and circuit identification shall be updated to reflect actual routing (new and existing).
3. Devices, appliances and components removed during construction shall be removed from drawings.
4. General notes, keyed notes and other notations on drawings explaining work to be performed during construction shall be removed.
5. Detail drawings shall be modified to reflect final conditions.
6. The revision block shall show a revised date and indicate that the revision is the “Record
Documents.

Additional drawings shall be developed where needed to accurately document final conditions.

1.08.3 Equipment Data Sheets and Calculations

Equipment data sheets shall be updated, if necessary, due to any approved equipment substitutions or review comments. Actual voltage, amperage and wattage readings taken during pre-testing and final testing shall also be included.

Calculations, as outlined in the submittal section, shall be revised due to any modified conditions or review comments.

1.08.4 Certifications

1.08.4.1 The certification from the major equipment (control panel) manufacturer indicating that the supervisor of installation is an authorized representative of the major equipment manufacturer. Include name and address in the certification.

1.08.4.2 The record of completion as required by NFPA 72.

1.09 SYSTEM ARRANGEMENT AND DESIGN

1.09.1 General Design and Layout Requirements

1.09.2 Reference and Background Drawings

Electronic copies of the contract background drawings will be made available to the Contractor upon request.

1.09.3 Fire Alarm System Arrangement

The following paragraphs describe the general panel configuration and pathway requirements for the new fire alarm system.

1.09.3.1 Network Configuration

The Fire Alarm System Control Panel shall be located as shown on the Fire Alarm Arrangement Drawings. The panel shall communicate with the base network control panels utilizing peer to peer network type technology. Network circuitry shall be Class X Fiber. Both legs of the fiber shall be routed (separately) to the Building 29 Data Closet.
1.09.3.2 Pathway Designations

Network circuitry shall match the base layout. Signaling line circuits shall be Class B. All alarm and supervisory initiating device circuits shall be Class B. Control circuits shall be Class B minimum. Notification appliance circuits shall be Class B.

1.09.3.3 Fire Alarm System Configuration

The Fire Alarm Control Panel shall be provided in the location noted on the Fire Alarm Arrangement Drawings. The exact location shall be coordinated with the Owner. The panel shall be a Simplex 4100-ES. The control panel shall be configured for addressable devices. The panel shall be provided with a dedicated 120-volt ac circuit with in line surge protection. The Contractor shall coordinate the panel and circuit number with the General Contractor.

The panel shall have integral power supplies for notification circuits. All power for the system shall be derived from the panel. Distributed power supplies and amplifiers, except as specifically noted are prohibited.

An annunciator shall be provided and located at the main entrance as shown.

Two Local Operating Consoles (LOC’s) shall be provided at this facility. Microphones, selector switches for pre-recorded messages and an air handler shut off switch shall be provided at each location.

1.09.3.4 Raceway

Raceway for all new circuitry shall be metallic conduit. Materials and routing requirements are noted in Parts 2 and 3.

Raceway for the network circuitry (data and voice) shall not be used for other fire alarm circuitry.

1.09.3.5 Wiring and Cable

The fire alarm network circuitry and audio riser circuitry shall be multi-mode fiber matching the existing network type.

All initiating device circuits shall be solid copper, 16 AWG and color coded for polarity. All notification appliance circuits will be solid copper, 14 AWG minimum and color coded for polarity. All circuit runs will be continuous (no splices).

1.09.3.6 Initiating Devices

The general locations of the fire alarm initiating devices are shown on the Fire Alarm Arrangement Drawings. These drawings show general locations and minimum number of devices only. Rooms provided with smoke or heat detectors shall be provided with the number of detectors required by the specific manufacturer’s recommendations and NFPA 72 requirements. The Contractor shall review the steel
drawings to determine ceiling type, and shall review the equipment and tray layouts for obstructions.

Exact placement of all initiating devices is the responsibility of the Contractor and subject to the review of the Engineer.

1.09.3.7 Notification Appliances

Fire alarm notification appliances shall be speaker/strobes in all areas of the building. Strobe only appliances may be used to meet ADA visual requirements in rooms where shown. The Fire Alarm Arrangement Drawings show locations for notification appliances. Exact placement of appliances is the responsibility of the Contractor and subject to the review and acceptance of the Engineer. Exact placement shall be in accordance with Part 3 of these specifications. Strobes shall be synchronized.

1.09.3.8 Building/System Interfaces

1. Elevator Detectors – Elevator lobby and machine room smoke detectors shall be programmed to create recall and in car notification signals. The elevator recall, in car notification and power shunt functions shall be accomplished by using supervised relays or addressable relay and control modules. Supervision of the 120volt ac power for the shunt trip breakers activation shall be provided. This supervision shall be accomplished as outlined on the riser diagram. The waterflow switch shall directly trip power to the elevator controller per UFC requirements.

2. HVAC Systems – The HVAC shutdown function shall be accomplished by using supervised relays or addressable relay modules from the panel as shown on the Arrangement Drawings or Riser Diagrams. The relays shall change state on the control circuit contacts on the HVAC unit for emergency shutdown.

1.10 SEQUENCE OF OPERATION

The sequence of operation of the system is outlined on the Fire Alarm Matrix on the Fire Alarm Arrangement Drawings.

In general, the alarm system shall operate as follows:

1.10.1 Alarm Signals

Any of the fire alarm initiating devices except HVAC smoke detectors, shall actuate all Readiness Center notification appliances. Additionally, sprinkler waterflow shall activate the outside horn/strobe. Duct detectors, shall activate the supervisory signal at the panel. All alarm initiating devices shall annunciate at the Fire Alarm Control Panel (FACP-1) and at the building's fire alarm annunciator as noted in Table 283100.

1.10.2 Supervisory Signals
Supervisory devices shall annunciate on the FACP and Annunciator as noted in Table 283100.

1.10.3 Trouble Signals

Trouble conditions shall cause the activation of a buzzer integral with the Panel and the Annunciator.

1.10.4 Other Building Systems

1.10.4.1 Elevators

Elevator recall shall be initiated by elevator lobby, hoistway and control room smoke detectors (panel function). Elevator power shutdown shall be initiated by the elevator hoistway and control room waterflow switch (directly). Elevator recall is programmed into the elevator controller as follows:

<table>
<thead>
<tr>
<th>Designated Level</th>
<th>Alternate Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Floor</td>
<td>2nd Floor</td>
</tr>
</tbody>
</table>

1.10.4.2 Air Handlers

Air handler shutdowns shall be on a unit-by-unit basis based on the activation of that unit's duct detectors (panel function).

1.10.5 Remote Monitoring

Any alarm, supervisory or trouble condition will cause the activation of a distinct signal on the base network control station.

1.11 WARRANTY

Complete warranty services for the new fire alarm system (components and installation) shall be provided, by a factory trained authorized representative of the manufacturer of the major equipment, during construction and for a period of two years, beginning at the conclusion of the acceptance test.

All equipment and materials shall be warranted to be free of mechanical and electrical defects by the Contractor/Manufacturer. Labor for replacement of failed equipment and materials shall be included. All software and programming shall be warranted to operate without disruption. All details of the installation shall be included in the warranty.

Service calls (normal) shall require response within six (6) hours of notification of system trouble. Emergency service call response time shall be two (2) hours and shall be limited to panels or other major components that affect the integrity of the system. Repairs shall be completed within 48 hours of notification. The Contractor shall show how they will provide this capability and furnish the Owner with a 24-hour service call number.
PART 2 – PRODUCTS

2.01 GENERAL

2.01.1 Materials

Equipment shall be furnished as outlined in the following subsections. Unless specifically provided otherwise, all materials and equipment furnished for permanent installation in the work shall conform to applicable standard specifications and shall be new, unused, and undamaged.

Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be of the same manufacturer and interchangeable.

All electronics shall be rated to withstand the temperature and humidity expected in the different areas of the building.

All alarm initiating devices shall be of the addressable type unless specifically noted otherwise.

2.01.2 Listing and Approvals

All equipment and devices furnished under these specifications shall be Factory Mutual (FM) approved or Underwriters Laboratories (UL) listed unless specifically noted otherwise.

All equipment, devices and appliances located in electrically classified areas shall be UL Listed for the classification hazard indicated or be on intrinsically safe circuit.

2.02 FIRE ALARM CONTROL PANELS

2.02.1 Network Fire Alarm Control Panel

The Network Fire Alarm Control Panel (FACP) shall be Simplex 4100 ES including the ACU for mass notification, and configured in accordance with NFPA 72 for Protected Premises Fire Alarm Systems. The panel shall be provided with hardware for surface or flush mounting as noted on the drawings. The panel shall have all components to operate on the existing base network and the following features:

1. The panel shall be of the addressable type and configured for peer-to-peer network interconnections. Occupant Notification shall be automatically activated voice with a manual override.

2. The panel shall be UL listed for operation with the proposed initiating devices and notification appliances.

3. Primary power for the panel shall be from the building’s 120-volt ac power and be provided with a battery backup. Upon failure of the normal power, the system shall automatically revert to the battery power without any interruption or loss of alarm, control, status or supervisory function. Operation of the system on secondary power shall be annunciated separately on the panel. All power for the entire system shall be derived from the panel.
and specifically noted distributed panels.

4. The battery system shall include a charger in compliance with NFPA 72. If the charger has a fast charge mode, a visual indicator shall be provided to annunciate this condition.

5. The batteries shall be located in a separate enclosure immediately adjacent to the FACP. The batteries shall be sized to operate the system under the maximum normal load for 24 hours and then be capable of operating the system two hours in the alarm condition per NFPA 72 requirements (15 minutes at maximum connected load). The system loads used to size the batteries (alarm and normal conditions) shall be a minimum of 20% above actual calculated loads. Batteries shall be sealed Lead-Acid.

6. The load connected to any one power supply shall not exceed 80% of its rated capacity (amperes).

7. The amplifier(s) shall be sized at least 20% above the calculated power requirements.

8. Notification appliance output circuits (zones) shall not be loaded beyond 60% of their rated capacity (amperage). Speaker circuits shall not be loaded beyond 70% of their rated capacity (wattage). A minimum of one additional speaker zone shall be provided for future use. Automatic messages shall be a female voice, with the following messages:

   Fire - A temporal 3 alert tone followed by “May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit or exit stairway. Do not use the elevator.”

   Carbon Monoxide - A temporal 4 alert tone followed by “Attention. Attention. Carbon Monoxide has been detected in the building. Please leave the building by the nearest exit.”

9. Annunciation within the panel shall include all devices indicated in Table 283100. The panel shall have an integral LCD annunciator. The label or wording shall be as outlined in Table 283100 and subject to the final review by the Engineer. Annunciation on the LCD display shall include the following information:

   a. Signal Level (Alarm, Supervisory or Trouble)
   b. Zone/Device Number
   c. Device Type
   d. Area Served

10. Each signaling line circuit and notification appliance zone shall be capable of being individually disabled with a supervised switch integral with the panel.

11. The panel shall annunciate the status of all devices listed in Table 283100 and common trouble for the panel on the base network.

12. The panel shall have the capability of storing and delivering at least eight pre-recorded messages. The messages shall be as directed by the Owner.
13. The panel shall be configured to allow manual voice paging that will override the automatic message system. Manual override during a fire alarm condition shall activate a supervisory signal. A permanently attached microphone with a minimum of a five-feet coiled cord shall be provided.

14. The ACU shall be configured for MNS communication with the Wide Area MNS to provide status information, receive commands, activate pre-recorded messages, and originate live voice messages; matching the existing Wide Area MNS of the Base.

15. Selective paging zones for manual messages shall be as follows:
   a. Zone RC-1
   b. Zone RC-2

The panel shall be able to accommodate any combination of zones activated at one time up to all zones.

16. The panel shall have a single programmed button to initiate strobe operation and message notification appliances throughout the Readiness Center.

17. The panel shall supervise all zones or points shown on the drawings or referenced in these specifications. An off normal status condition of any point shall be transmitted (distinct message) across the network to the network annunciators.

18. The panel shall be provided with all software (installed) necessary for panel programming. If any additional hardware or software is required beyond that of a standard Windows® based computer, it shall be provided.

19. The panel door shall be provided with a permanent nameplate identifying it as directed by the Owner.

2.03 PANEL COMPONENTS

2.03.1 Remote Annunciator Panel

The annunciator shall have an LCD display type. The annunciator shall display the status of all devices, identical to the FACP display. Annunciator power shall be provided from the FACP. The annunciator shall be UL listed or FM approved for use with the FACP.

2.03.2 Local Operating Console (LOC)

Each Local Operating Console shall have the following features:

1. Power for the LOC shall be from the FACP.
2. The panel shall be configured so that it will override any automatic messages.
3. Pushbuttons to activate each of the pre-recorded messages.
3. A permanently attached microphone with a minimum of a 10-feet coiled cord.

4. Activation of the pushbuttons or the microphone key shall initiate all strobes and message notification appliances.

6. Panel controls shall include the HVAC shutdown switch.

7. The panel door shall be provided with a permanent nameplate identifying it as directed by the Owner.

8. Provide and install a second microphone, holder and baseplate (PA microphone) outside and adjacent to each LOC for non-emergency paging.

2.04 RACEWAY AND WIRING

2.04.1 Raceway

Unless specified otherwise, all raceway, interconnections between devices, panels, boxes, and fittings shall conform to ANSI C80.3 and UL 797(EMT). Flexible conduit (not pre-wired) may be used as specifically allowed in Part 3 of these specifications.

The electrical raceway system shall be furnished and installed by the Contractor. Conduit shall include all fittings and supports and all flexible conduit and fittings. Electrical conduit and associated materials shall be metallic and conform with the requirements of the codes and standards listed in this section.

Raceway and conduit systems shall be provided with permanent labels at every junction box cover indicating that fire alarm wiring is within. All junction box covers shall be painted red. Labels shall be subject to acceptance by the Engineer. The raceway system provided for all interconnecting wiring shall be acceptable to the Owner.

2.04.1.1 Minimum Conduit Size

The minimum allowable conduit size shall be 3/4-inch.

2.04.1.2 Conduit Supports

Conduit supports shall be furnished in accordance with these specifications. Support material shall comply with the requirements which follow.

2.04.1.3 Hanger Rods

Hanger rods shall be electro-galvanized all-thread steel rods.

2.04.1.4 Conduit Clamps

Supports for conduits in single runs or groups of two shall be one-hole cast metal clamps and
clamp-backs. They shall be galvanized malleable iron or acceptable equal cast ferrous metal for steel conduit.

Supports for banks of three or more conduits shall be constructed of support channels (Unistrut, Kindorf, or acceptable equal) with associated conduits clips. Support channels shall be fabricated from hot-dip galvanized steel. Any exposed steel after installation shall be touched up with Zinc Oxide.

2.04.1.5 Conduit Bodies, Boxes, and Enclosures
Conduit bodies, boxes, and enclosures installed outdoors shall be raintight.

2.04.1.6 Fittings
Raintight fittings shall be used throughout the raceway system.

2.04.2 Cable and Wire

The type of cable or wire chosen should be based on fire alarm system requirements, specification requirements and applicable code requirements. Consideration should also be given to the length of cable runs and potential interference.

All wiring provided on this project shall be in accordance with NFPA 70, Article 760, for the intended wire use.

2.04.2.1 Fiber Optic Cable

All network circuitry shall utilize fiber optic cable. This cable shall be UL Listed for the intended purpose. The fiber type shall be in accordance with the fire alarm manufacturer’s recommendations. At least two spare fibers shall be provided in each cable.

The cable shall be UL Listed for the intended purpose. The fiber type shall be multi-mode in accordance with the fire alarm manufacturer’s recommendations. The cable shall be rated for a minimum pull strength adequate for the requirements of the installation, and be suitable for indoor installations in a conduit raceway system. At least two spare fibers shall be provided in each cable.

2.04.2.2 Metallic Cable/Wire

All electrical wire shall be selected for the electrical and environmental conditions of the installations and shall be of the best construction for the service where unusual service conditions are encountered. Proper temperature application wire shall be used throughout. Except where required to be otherwise to perform satisfactorily in the service, all electrical conductors shall be solid copper, minimum 16 AWG for initiating device, signaling line and control circuits and minimum 14 AWG for visual notification appliance circuits. Wire type for the voice circuitry shall be as recommended by the Manufacturer and shall be a minimum of 18 AWG. Wire and cable shall be twisted and shielded if recommended by the system manufacturer. Initiating, signaling line and control circuits shall be sized (above minimums noted above) based on 20% additional power consuming devices on a 30% longer circuit. Notification appliance circuits (speakers and strobes) shall be sized (above minimums noted) based on 50% additional appliances on a 30% longer circuit.
circuit. The number of additional power consuming devices required per circuit shall be rounded up and the additional power consuming devices shall be equal to the largest power consuming device on the circuit.

General Service power cables for the equipment furnished but not internal wiring of control cabinets or panels, shall be rated for the maximum service voltage but not less than 600 volts.

Wire chosen shall be color coded to indicate the type of circuit (i.e. detector, waterfall, manual fire alarm box, telephone, bell, strobe, etc.). The color coding schedule shall be as follows:

<table>
<thead>
<tr>
<th>Type of Circuit</th>
<th>Wire Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signaling Line Circuits (cable is acceptable)</td>
<td>Red with tracer</td>
</tr>
<tr>
<td>Waterflow Switches</td>
<td>Blue</td>
</tr>
<tr>
<td>Manual Fire Alarm Boxes</td>
<td>Red</td>
</tr>
<tr>
<td>Smoke Detectors</td>
<td>Purple</td>
</tr>
<tr>
<td>Heat Detectors</td>
<td>Orange</td>
</tr>
<tr>
<td>Duct Smoke Detectors</td>
<td>Gray</td>
</tr>
<tr>
<td>Supervisory Devices</td>
<td>Brown</td>
</tr>
<tr>
<td>Notification Appliances</td>
<td>Yellow</td>
</tr>
<tr>
<td>Notification Appliances (Speakers) (Cable is acceptable)</td>
<td>Green (or red with green tracer)</td>
</tr>
<tr>
<td>Control Circuits</td>
<td>Black</td>
</tr>
</tbody>
</table>

The neutral side of the circuit shall have the circuit color as a tracer on a white wire for any circuit where the devices or appliances require polarization. Alternate colors may be proposed by the Contractor, due to wire availability; however, are subject to Engineer acceptance.

2.04.3 Surge Protective Devices

In line surge protection shall be provided for all 120-volt ac interfaces with fire alarm equipment. These devices shall be listed in accordance with UL Standard 1449 (3rd Edition). 120 Volt ac surge protection devices shall be of the self-restoring type, provided with terminal connections and an LED indication of the protection status. The devices shall meet the following criteria:

- Protector Type: Type 1 SPD or Type 2 SPD
- Operating Current: 20 Amps
- Maximum Continuous Operating Voltage: 150 vac
- Peak Surge Current: 40,000 Amps
- Response Time: <5 ns

2.05 INITIATING DEVICES

2.05.1 Manual Fire Alarm Boxes

Manual fire alarm boxes shall be addressable, double action type and require a key to reset. Factory mounted terminals shall be provided for external wiring terminations.

2.05.2 Smoke Detectors
2.05.2.1 Smoke detectors shall be of the solid state photoelectric type.

2.05.2.2 The detector shall contain an alarm indicating LED which shall change state upon activation of the detector.

2.05.2.3 Detectors shall be listed by UL as “Smoke-Automatic Fire Detectors” tested in accordance with UL 268. Detector sensitivity shall be set at the factory as required by UL 268. The Contractor shall be responsible for determining the correct sensitivity range for the particular applications.

2.05.2.4 For ease of maintenance and installation, detectors shall be designed for twist-lock mounting to a separate base assembly having screw terminals for external wire connections.

2.05.2.5 The detector shall either be equipped with a calibrated test feature which will test detector sensitivity and operation, or equipment shall be provided as a part of the contract to test the sensitivity in accordance with NFPA 72.

2.05.3 Duct Smoke Detectors

Duct smoke detectors shall be of the photoelectric type and listed for use with the control panel provided under this contract. The detector shall operate on Fire Alarm Control Panel power. The Contractor shall be responsible for determining the proper factory set sensitivities for each unit.

The Contractor shall review the arrangement drawings and confirm that the proposed detector(s) is Listed for the environments (temperature, humidity, etc.) shown.

A remote test station and alarm indicator shall be provided for each unit where the detector is more than six feet above the floor or where activation cannot be achieved without disassembly of the unit. The remote test station and alarm indicator shall be suitable for wall mounting and shall be an LED type. The unit shall have a key switch for testing.

2.05.4 Carbon Monoxide Detectors

The detector shall be UL Listed for operation with and powered by the fire alarm panel. Detectors shall be UL Listed in accordance with UL 2075 and set to respond to the sensitivity limits of UL 2034. A multi criteria detector will be considered if the other criteria is limited to heat. The multi criteria detector shall be able to send distinct signals for CO and heat. The detector shall send a trouble signal for end of life in 6 months and at the end of life.

2.06 NOTIFICATION APPLIANCES

2.06.1 Occupant Notification Appliances

Fire alarm notification appliances shall be speaker or speaker/strobes except where specifically noted otherwise.

Speakers shall operate on 25 volts ac. Speakers shall have multiple output wattage taps with a minimum range of 1/4 to 2 watts. The output shall meet or exceed the sound level required for the
room or area in accordance with NFPA 72 requirements. The speakers shall not utilize the highest wattage tap to obtain the required sound level. The speakers chosen shall be suitable for the acoustics of the building. Final acceptance of the appliances is subject to measurement (0.8 CIS).

Strobes shall operate on 24 volts dc. The strobes shall have a clear lens with the word “Alert” in one-inch minimum height letters. The strobe intensity and design shall meet or exceed ADA requirements and UL 1971 requirements. Minimum candela ratings shall be as noted on the drawings.

Wall mounted appliance housings shall be white. Ceiling mounted speakers shall be white. These appliances shall be factory polarized if polarization is required to operate with the fire alarm system. Factory mounted terminals shall be provided for external wiring connections.

The appliance and its backbox shall be listed by the manufacturer as watertight (NEMA 4) when the appliance is installed outdoors.

2.06.2 Message Notification Appliances

LED type exit signs shall comply with UL 48 and UFC 4-021-01. The appliances shall illuminate either the “EVACUATE” or “ANNOUNCEMENT” message. The sign shall operate on 24vdc and shall be capable of being supervised by a reverse polarity circuit. Automatic fire alarm actuation shall initiate the “EVACUATE” message. Other pre-recorded messages or a manual message shall activate the “ANNOUNCEMENT” message. Illumination of the message will continue throughout the fire alarm condition and for 10 seconds after the MNS audible message is complete.

2.07 BUILDING SYSTEM INTERFACE DEVICES

2.07.1 Addressable Monitor, Control Modules and Relay Modules

Addressable monitor, control modules and relay modules where used, shall be UL listed for operation with the fire alarm panel. Monitor and control modules shall supervise the conventional (hard-wired) circuitry to the device or component supervised. Minimum conventional circuit style shall be Class B (Style B). Interface modules shall have LED’s (visible without opening boxes) to differentiate between normal operation and alarm state. Factory mounted terminals shall be provided for all external wiring connections.
PART 3 – EXECUTION

This section covers the installation and installation material requirements for the fire alarm system.

3.01 GENERAL

3.01.1 Personnel

As noted in Part 1, the Installation Supervisor shall be on the job site during the entire installation. The supervisor shall have all contract documents on site at all times. The supervisor shall also have a copy of all submittals (shop drawings and all other documentation). The supervisor shall be responsible for daily updating of the shop drawings and other data to reflect the actual installation (red-lines). These drawings shall be made available to the Owner or Engineer for review at any time.

The existing portions of this facility will continue in operation during the construction period. Construction shall be coordinated with the Owner to minimize disruption to the facility’s general operation. The Contractor’s personnel shall abide by all security and safety requirements of the Owner.

3.01.2 Working Hours

Working hours shall be coordinated with the General Contractor.

3.01.3 Construction Phasing

Construction phasing shall be coordinated with the General Contractor and Sprinkler Contractor.

3.01.4 Impairment of Existing Alarm System

All modifications of the existing mass notification system in Phase 3A shall be staged to limit the frequency and duration of alarm system impairments. The Contractor shall notify the Owner in writing at least 24 hours in advance of any impairments. The system shall not be left unattended in an impaired state.

3.02 RACEWAY AND WIRING INSTALLATION SCOPE

The Contractor shall furnish and install all required conduit and all associated hardware (except as specifically noted otherwise), and shall furnish, install (pull), connect, and test all cable for a complete fire alarm system. All wiring shall be installed in accordance with the guidelines of these specifications and documents as well as the NFPA codes and standards listed in these specifications.

3.02.1 Wiring and terminations specifically included under this section includes, but is not limited to the following:

1. 120-volt ac power (dedicated branch circuit) to the Fire Alarm Control Panel.
2. Installation of the surge suppressor, associated ground circuitry and termination of
the 120-volt ac circuitry at the fire alarm panel.

3. Between the Readiness Center FACP and the Building 29 Data Closet.
4. Between all components of the mass notification system.
5. Between the FACP and its associated batteries.
6. Between all initiating devices, notification appliances, and components supplied under this section and the Fire Alarm Control Panel.
7. Between the Fire Alarm Control Panel and the annunciator.
8. Between the waterflow switches, and valve tamper switches on the fire suppression systems and the Fire Alarm Control Panel.
9. From the monitor control and relay modules to the elevator disconnect and controller. The Contractor shall leave sufficient wire to connect to the most remote elevator equipment contacts without splicing. Termination of the circuitry within the elevator disconnect and controller will be performed by the Elevator Contractor, in the Fire Alarm Contractor’s presence. Pre-testing of this circuit shall be performed at this time.
10. From the relay modules to the HVAC controller shutdown contacts.
11. All additional wiring required, not specifically excluded, for a complete operational system.

3.02.2 The Contractor shall furnish and install a complete electrical wiring, cable and conduit system as outlined in these specifications for a complete operating system.

3.03 RACEWAY INSTALLATION

3.03.1 General

All wire and cable shall be installed in conduit. Network circuitry shall be run in dedicated conduit. Conduit installation shall be as required by the Contractor’s layout and as described in these specifications. All conduit field routing is subject to acceptance of the Owner. Routing not acceptable shall be rerouted and replaced without expense to the Owner.

3.03.2 Class X Raceway

Redundant conduit shall be provided as required by NFPA 72 for Class X circuitry.

Redundant conduit for Class X circuitry shall be separated by a minimum four feet for horizontal conduit and a minimum one foot for vertical conduit.

3.03.3 Concealing

All wire, cable, conduit and raceways shall be concealed in walls, ceiling spaces, electrical shafts
or closets in finished areas except as specifically noted otherwise. Conduit and raceways may be exposed in unfinished areas or where specifically approved by the Owner.

3.03.4 Sizing

Minimum allowable conduit size shall be ¾-inch. The conduit shall be sized so that conduit fill does not exceed 75% of NFPA 70 maximum fill requirements. Cables in vertical risers shall not exceed 50% of NFPA 70 maximum fill requirements.

3.03.5 Routing

Except as otherwise specified or indicated on the drawings, all raceway shall be installed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Raceway shall be routed as close to the structure as possible. Raceway shall not be less than 18 inches above ceiling tiles in finished areas. Except where prevented by the location of other work, a single conduit or a conduit group shall be centered on structural members.

Conduit shall be located at least six inches from hot water or steam pipes, and from other hot surfaces. Conduit shall not block access to any existing equipment or fixtures.

Buried conduit shall be buried at least 2 feet below grade and provided with a copper tracer wire. Exterior wall penetrations shall be sealed to prevent moisture from entering the building.

3.03.6 Moisture Pockets

Moisture pockets shall be eliminated from conduits. If water cannot drain to a natural opening in the conduit system, a breather fitting shall be installed in the bottom of a pull box or a “C-type” conduit fitting provided in the low point of the conduit run.

3.03.7 Bends and Offsets

A run of conduit shall not contain more than the equivalent of four quarter bends, including those immediately at outlets or fittings. Bends in conduit shall be made without reducing the internal diameter of the conduit. The use of a pipe tee or vise for bending conduit is prohibited. The inside radius of conduit bends shall be not less than six times the inside diameter of the conduit. Conduits deformed or crushed in any way shall be removed from the job site. Conduit for fiber cables shall meet the minimum requirements noted above and all of the more restrictive fiber requirements of NFPA 70 and manufacturer's requirements.

3.03.8 Connections to Boxes and Cabinets

Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit shall project through the wall of the box to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to bond the conduit securely to the box. Conduit shall enter cabinets or boxes with terminations or electronic equipment from the bottom and sides only.

3.03.9 Cleaning
3.03.10 Flexible Conduit

Flexible conduit inserts shall be installed in all conduit runs which are supported by both building steel and by structures subject to vibration or thermal expansion.

Flexible conduit shall be installed in conduit runs which cross expansion joints or which connect to building supported independent structures such as ceiling tiles.

The necessity for flexible conduit inserts shall be considered in all long conduit runs where differential expansion problems may be expected.

Flexible conduit shall be limited to eight feet in length. Field conditions which require longer lengths shall be referred to the Engineer for acceptance.

3.03.11 Spacing and Attachment of Supports

All conduit runs shall be rigidly supported. Each conduit shall be supported within one foot of junction boxes and fittings. Support spacing along conduit runs shall be as outlined in NFPA 70.

3.04 CABLE AND WIRE INSTALLATION

3.04.1 General

Cable and wire shall be installed per the general schematic routing identified on the riser diagrams, and further detailed for the specific equipment provided for this project. In general, wiring shall extend from the panel, landing and passing through devices, appliances and other components. Tee taps are prohibited unless specifically allowed by illustration on the riser diagrams. Field splicing of circuits between devices, appliances or other components is prohibited unless specifically allowed by illustration on the riser diagrams.

3.04.2 Terminations

All field wiring shall terminate on terminal blocks in fire alarm panels and at field devices and appliances. Devices, appliances or components without terminal connectors shall be submitted for approval prior to shop drawing submittal. Where approved, these devices, appliances or components shall be installed "on or" in a junction box with a labeled terminal strip for connections. The terminal strip shall be permanently mounted on binding posts at the front or top of the junction box for accessibility.

Connections using wire nuts are prohibited.

3.04.3 Identification

The Contractor shall identify the ends of all circuits. The Contractor shall also identify all circuits
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in pull and junction boxes. A conductor identification sleeve shall be provided on each end of each internal conductor. Conductor identification shall be permanent, unaffected by heat, solvents, or steam, and not easily dislodged. Each marker shall bear the number of the circuit according to the drawings. One end of each marker shall remain free of the fastening tail, and the entire marker shall be so attached that it is readily visible for circuit identification. Sample conductor markers shall be submitted for review and acceptance.

3.05 EQUIPMENT LOCATIONS AND INSTALLATION

3.05.1 General

All equipment shall be installed in accordance with these specifications, the codes and standards listed as well as the manufacturers guidelines. All initiating devices (including those provided and installed under SECTION 211300), notification appliances and any other equipment or devices located external to the fire alarm panel, shall be provided with typed, self-adhesive labels (permanent) indicating device and/or circuit numbers. All field equipment, including interface devices, initiating devices and notification appliances shall be located in compartments, enclosures or junction boxes, in such arrangement that a service personnel will have direct access to the equipment without disturbing other building equipment or utilities.

3.05.2 Fire Alarm Panel/Battery Enclosure

The fire alarm system panel and LOC panels and the FACP battery enclosure shall be mounted (surface or flush) and located in the as noted on the fire alarm arrangement drawings. Exact locations are subject to the approval of the Engineer and Owner. The panel components shall be assembled and burned in for at least 24 hours prior to attaching field circuits.

3.05.3 Annunciator Panel

The annunciator panel shall be located on the at the main entrance as noted on the arrangement drawing. The panel shall be flush mounted. The exact location shall be subject to the approval of the Owner.

3.05.4 Manual Fire Alarm Boxes

Manual fire alarm boxes shall be flush mounted in all finished spaces and in other spaces where possible. Mounting height shall be 48 inches from the floor to the top of the fixture. Exact location shall be subject to the approval of the Engineer.

3.05.5 Smoke Detectors

Smoke detectors shall be mounted in flush mounted boxes in areas with finished ceilings. Smoke detectors may be surface mounted on the structure in unfinished areas. Locations and quantities shall be in accordance with these specifications, contract drawings, applicable codes and the
Manufacturer’s guidelines.

3.05.6 Duct Smoke Detectors

Duct smoke detectors shall be located in the general locations shown on the arrangement drawings and in accordance with NFPA 72 and NFPA 90A, and manufacturer’s requirements. The exact locations shall be determined by the Contractor.

Duct air velocity, humidity and temperature shall be measured at intended duct detector locations prior to installation. Room temperature and humidity shall be also measured at the selected location. The Contractor shall verify that the environment measured complies with Manufacturer’s recommendations and the listing for the equipment selected. A new location shall be selected if the environment measured falls outside the allowed limits. Required parameters and measurements for each duct detector shall be submitted with the Contractor’s preliminary test results.

After installation of the duct detector enclosures, sampling tube and exhaust tube, the Contractor shall verify air flow through the duct detector by measuring the static pressure difference between the inlet and outlet tubes using a manometer or other method approved by the Manufacturer. Duct detectors shall be relocated if the pressure differential specified by the Manufacturer cannot be attained at the selected location. Required parameters and measurements for each duct detector shall be submitted with the Contractor’s preliminary test results.

A remote test station and alarm indicator shall be provided for each unit where the detector is more than six feet above the floor or where activation cannot be achieved without disassembly of the unit. The remote alarm indicators and test stations, where required, shall be located on columns or walls (four feet above the floor) as near the duct detector as possible (flush mounted in finished areas) unless specifically noted otherwise on the fire alarm arrangement drawings. Remote alarm indicators shall be clearly marked as to their associated air handler.

3.05.7 Carbon Monoxide Detectors

Carbon Monoxide detector shall be flush mounted on the ceiling of the kitchen. Locations and quantities shall be in accordance with these specifications, contract drawings, applicable codes, and manufacturers’ guidelines.

3.05.8 Addressable Monitor, Relay and Control Devices

Addressable monitor devices shall be installed in surface mounted boxes within four (4) feet of waterflow and valve tamper switches. Indicators displaying normal or abnormal conditions shall be visible from the floor.

Addressable control or relay modules shall be located within three (3) feet of the device being controlled. These devices shall be flush mounted in the ceiling tiles where the components being controlled are located above finished ceilings.

3.05.9 Surge Protective Devices

Surge protective devices shall be located in dedicated junction boxes or enclosures and labeled as required for devices and box covers. The 120 volt ac surge protectors for the fire alarm panel shall
be located immediately outside the associated panel, and per manufacturers’ recommendations. Ground circuits for surge protective devices shall be per manufacturer’s instruction manuals and NFPA 70.

3.05.10 Notification Appliances

The minimum locations of notification appliances are shown on the contract drawings. The appliances’ exact location shall be proposed by the Contractor and are subject to the acceptance of the Engineer. In general, wall mounted visual appliances shall be located so that the entire lens is not less than 80 inches (or 6 inches below the ceiling), and not greater than 96 inches above the highest floor level within the space. The placement along the wall shall be chosen to provide the best field of viewing from any place within the room or area. The appliances shall be flush mounted in all finished spaces and in other spaces where possible.

The number of, spacing and sound levels of individual audible appliances shall be chosen to meet or exceed NFPA 72 required sound levels and meet CIS values throughout the room or area.

The Contractor shall be responsible to verify actual conditions and install the correct appliances based on the findings.

3.05.11 Message Notification Appliances

Textual notification appliances shall be flush mounted and located immediately above the doors where shown on the contract drawings.

3.06 FIRESTOPPING

Firestopping shall be provided where conduit penetrates fire rated walls and all floors. See the Architectural drawings for locations and ratings.

Firestopping shall have a rating equivalent to the rating of the wall or floor being penetrated (2 hours unless noted otherwise). Firestopping materials and methods shall be in accordance with a specific Underwriters Laboratories Listed System for the materials being penetrated.

3.07 DEMOLITION

Wall and floor openings created by the Contractor or removed component shall be sealed with materials matching the existing element’s construction. Repair methods and materials shall maintain any existing element’s fire rating and are subject to the Engineer's approval.

3.08 TRAINING

Training shall be provided for the operations and maintenance staff. Training shall be conducted in the building where the system is installed or as designated by the Owner. The training period shall be a minimum of one 4-hour session and shall start after the system is functionally completed but prior to the final acceptance test. The Training session shall cover all of the items contained in the operating and maintenance instructions.

3.09 SYSTEM TESTS
3.09.1 General

This sub-section covers testing of the fire alarm systems furnished and installed under these specifications.

All labor and equipment for testing shall be the responsibility of the Contractor. A sufficient number of Contractor personnel shall be available to monitor all panels and annunciators as well as test the field devices. All personnel shall have radios or telephones that operate within the building for communication.

3.09.2 Pre-Tests

The Contractor shall completely pre-test each component of the system after installation is complete and prior to the final acceptance test. The Contractor shall notify the Engineer in writing of the proposed test date at least two weeks in advance. All defects discovered by pre-testing shall be corrected and the systems retested. The Contractor shall provide written confirmation of the results of the pre-test, including the duct smoke detector manometer readings, to the Engineer at least 48 hours before the final acceptance test. The test date and time is subject to the approval of the Engineer.

The pre-test shall include but not be limited to the following tests:

3.09.2.1 Field Wire and Cable Tests

Each circuit shall be tested as follows:

3.09.2.1.1 Stray Voltages. Verify that stray (unwanted) voltages that could constitute a hazard or prevent proper system operation do not exist between the installation conductors and ground or between installation conductors.

3.09.2.1.2 Ground Faults. All installation conductors other than those intentionally and permanently grounded should be tested for isolation from ground using an insulation testing device that will not damage connected equipment.

3.09.2.1.3 Short Circuit Faults. All installation conductors other than those intentionally connected together should be tested for conductor-to-conductor isolation using an insulation testing device.

3.09.2.1.4 Fiber Optic Continuity. Test each section of the fire alarm and spare fiber optic cable fibers for continuity and signal strength. A fiber optic certification test report is required for each section of the cable.

3.09.2.1.5 Circuit Resistance. With each signaling line circuit, initiating, notification appliance, and control circuit conductor pair short-circuited at the far end, measure and record the resistance of each circuit. Verify that the loop resistance, voltage drop and current do not exceed the Manufacturer’s specified limits. Records of readings from these tests shall be submitted to the Engineer with a copy of the Manufacturer’s requirements on all external
3.09.2.1.6 Normal and Alarm Mode Current Draw. The system current shall be measured in the normal mode and alarm mode, with 100% of the devices in alarm, to confirm numbers used in battery and power supply calculations. Actual readings shall be submitted to the Engineer.

3.09.2.2 Component Test

3.09.2.2.1 Each device and appliance shall be functionally tested. New duct smoke detectors shall be tested for proper air flow.

3.09.2.2.2 Signaling, initiating, notification and control device circuits shall be tested to confirm their integrity underground and short circuit conditions as required by their class.

3.09.3 Final Testing

The completed system shall be tested by the Contractor and witnessed by the Owner and the Engineer. The Owner and Engineer shall be notified of the proposed test date at least 96 hours in advance. The request for testing shall be accompanied by the pre-test results, the Record Documents as required in Section 1.08 (Final Documentation) and a copy of the red-lines. The date and time for the test is subject to the approval of the Owner and Engineer. The Contractor shall be responsible to coordinate testing with the City. Testing shall be in accordance with all applicable city building and fire codes, and the referenced NFPA codes, as well as the following specific requirements:

1. The 120-volt ac power to the Fire Alarm System Panels shall be turned off 24 hours prior to the test time. The first test will put each system into alarm for 15 minutes. Battery voltage and current readings shall be taken by the Contractor to verify calculations and power supply capacities.

2. Engineer selected circuits shall be tested for shorts, ground and open conditions. Appropriate fire alarm panel reaction, based on the circuit’s style shall be verified.

3. Each initiating device, control device and notification appliance on each circuit shall be tested.

4. Sound level and intelligibility readings shall be taken throughout the building.

5. Transmission of all signals to the Fire Alarm Control Panel, annunciators, proprietary station and other auxiliary devices shall be verified.

6. Supervisory functions of all circuits and transmission of all fault signals to the Fire Alarm Control Panel shall be verified.

8. All pre-recorded emergency voice messages shall be verified.

9. The Contractor shall supply the Owner and Engineer with a written report certifying
that all equipment has been inspected and tested by a Manufacturer’s certified representative.

The Owner or Engineer may terminate the acceptance test at any time based on an unacceptable number or magnitude of deficiencies.

If the system fails the test, the Contractor shall be responsible for the costs for the Owner and the Engineer for additional testing.

Final acceptance of the alarm system shall be based on satisfactory completion of all items listed above and trouble free operation for a period of 30 days after completion of the tests.

TABLE 283100 DEVICE LIST TO FOLLOW
### TABLE 283100 - FIRE ALARM SYSTEM ANNUNCIATOR SCHEDULE

<table>
<thead>
<tr>
<th>DEVICE NUMBER</th>
<th>DEVICE TYPE</th>
<th>AREA SERVED</th>
<th>DEVICE LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Floor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A.1.101</td>
<td>Waterflow Switch</td>
<td>Readiness Center</td>
<td>Phase 3A Valve Station</td>
</tr>
<tr>
<td>3A.1.701</td>
<td>Valve Tamper Switch</td>
<td>Valve Station Isolation Valve</td>
<td>Phase 3A Valve Station</td>
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<tr>
<td>Readiness Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Floor</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RC.1.111</td>
<td>Waterflow Switch</td>
<td>Sprinkler System Zone RC-1</td>
<td>RC Valve Station</td>
</tr>
<tr>
<td>RC.1.121</td>
<td>Waterflow Switch</td>
<td>Sprinkler System Zone RC-2</td>
<td>RC Valve Station</td>
</tr>
<tr>
<td>RC.1.201</td>
<td>Manual Fire Alarm Box</td>
<td>South Door</td>
<td></td>
</tr>
<tr>
<td>RC.1.202</td>
<td>Manual Fire Alarm Box</td>
<td>Mech/Elec Rm Door</td>
<td></td>
</tr>
<tr>
<td>RC.1.203</td>
<td>Manual Fire Alarm Box</td>
<td>Heated Storage Exit</td>
<td></td>
</tr>
<tr>
<td>RC.1.204</td>
<td>Manual Fire Alarm Box</td>
<td>LATR Hallway Exit</td>
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</tr>
<tr>
<td>RC.1.205</td>
<td>Manual Fire Alarm Box</td>
<td>Northwest Corridor Exit</td>
<td></td>
</tr>
<tr>
<td>RC.1.206</td>
<td>Manual Fire Alarm Box</td>
<td>North Door</td>
<td></td>
</tr>
<tr>
<td>RC.1.301</td>
<td>Smoke Detector</td>
<td>FACP</td>
<td>Telephone Room</td>
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</tbody>
</table>

**FIRE ALARM SYSTEM**
### TABLE 283100 - FIRE ALARM SYSTEM ANNUNCIATOR SCHEDULE

<table>
<thead>
<tr>
<th>DEVICE NUMBER</th>
<th>DEVICE TYPE</th>
<th>AREA SERVED</th>
<th>DEVICE LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC.1.303</td>
<td>Smoke Detector</td>
<td>Elevator Lobby</td>
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<tr>
<td>RC.1.501</td>
<td>Duct Smoke Detector</td>
<td>Shutdown Air Handler AHU-1</td>
<td>Air Handler - Supply</td>
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<tr>
<td>RC.1.601</td>
<td>CO Detector</td>
<td>Kitchen</td>
<td></td>
</tr>
<tr>
<td>RC.1.605</td>
<td>Kitchen Hood Alarm Contact</td>
<td>Kitchen</td>
<td></td>
</tr>
<tr>
<td>RC.1.711</td>
<td>Valve Tamper Switch</td>
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<td>Waterflow Switch</td>
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<td>North Corridor Door</td>
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<td>Waiting Room Door</td>
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<td>Smoke Detector</td>
<td>Elevator Lobby</td>
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<td>RC.2.302</td>
<td>Smoke Detector</td>
<td>Elevator Hoistway</td>
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### TABLE 283100 - FIRE ALARM SYSTEM ANNUNCIATOR SCHEDULE

<table>
<thead>
<tr>
<th>DEVICE NUMBER</th>
<th>DEVICE TYPE</th>
<th>AREA SERVED</th>
<th>DEVICE LOCATION</th>
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<tr>
<td>RC.2.303</td>
<td>Smoke Detector</td>
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<td>Duct Smoke Detector</td>
<td>Shutdown Air Handler AHU-2</td>
<td>Air Handler - Supply</td>
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<td>Addressable Monitor Module</td>
<td>Power Shunt Control Power Trouble</td>
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<td>Addressable Relay Module</td>
<td>Shutdown Air Handler AHU-1</td>
<td>AHU Room</td>
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<td>Addressable Relay Module</td>
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<td>Elevator In Car Notification</td>
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END OF SECTION 283100
SECTION 311000 CLEARING AND GRUBBING

PART 1 – DESCRIPTION

1.1 SUMMARY

A. This item shall consist of clearing or clearing and grubbing, including the disposal of materials, for all areas within the limits designated on the plans or as required by the Engineer.

B. Clearing shall consist of the cutting and removal of all trees, stumps, brush, logs, hedges, the removal of fences and other loose or projecting material from the designated areas.

C. Clearing, when so designated, shall consist of the cutting and removal of isolated single trees or isolated groups of trees. The cutting of all the trees of this classification shall be in accordance with the requirements for the particular area being cleared, or as shown on the plans, or as directed by the Engineer. The trees shall be considered isolated when they are 40 feet (12 m) or more apart, with the exception of a small clump of approximately five trees or less.

D. Clearing and grubbing shall consist of clearing the surface of the ground of the designated areas of all trees, stumps, down timber, logs, snags, brush, undergrowth, hedges, heavy growth of grass or weeds, fences, structures, debris, and rubbish of any nature, natural obstructions or such material which in the opinion of the Engineer is unsuitable for the foundation of strips, pavements, or other required structures, including the grubbing of stumps, roots, matted roots, foundations, and the disposal from the project of all spoil materials resulting from clearing and grubbing by removal from the site.

PART 2 – CONSTRUCTION METHODS

2.1 GENERAL.

A. The clearing or clearing and grubbing shall be done at a satisfactory distance in advance of the grading operations.

B. All spoil materials removed by clearing or by clearing and grubbing shall be disposed of by removal to approved disposal areas.

C. As far as practicable, waste concrete and masonry shall be placed on slopes of embankments or channels. When embankments are constructed of such material, this material shall be placed in accordance with requirements for formation of embankments. Any broken concrete or masonry which cannot be used in construction, and all other materials not considered suitable for use elsewhere, shall be disposed of by the Contractor. In no case shall any discarded materials be left in windrows or piles adjacent to or within the airport operation area. The manner and location of disposal of materials shall be subject to the approval of the Engineer and shall not create an unsightly or objectionable view. When the Contractor is required to locate a disposal area outside the airport property limits at his/her own expense, he shall obtain and file with the Engineer, permission in writing from the property owner for the use of private property for this purpose. In no case shall suitable soil be removed from the airport property. However, unsuitable soils must be removed from airport property.

D. The use of explosives will not be allowed.

F. The removal of existing utilities required to permit orderly progress of work shall be accomplished by local agencies, unless otherwise shown on the plans. Whenever a telephone or telegraph pole, pipeline,
conduit, sewer, roadway, or other utility is encountered and must be removed or relocated the Contractor shall advise the Engineer who will notify the proper local authority or owner and attempt to secure prompt action.

2.2 CLEARING.

A. The Contractor shall clear the indicated area of all objectionable materials. Trees unavoidably falling outside the specified limits must be cut up, removed, and disposed of in a satisfactory manner. In order to minimize damage to trees that are to be left standing, trees shall be felled toward the center of area being cleared. The contractor shall preserve and protect from injury all trees not to be removed.

B. When isolated trees are designated for clearing, the trees shall be classed in accordance with the butt diameter size as measured at a point 18 inches above the ground level or at a designated height specified in the proposal.

C. Fences shall be removed and disposed of when directed by the Engineer. Fence wire shall be neatly rolled, and the wire and posts stored on the airport if they are to be used again, or stored at a designated location if the fence is to remain the property of a local owner or of a civic authority.

2.3 CLEARING AND GRUBBING. Not Used.

2.4 REMOVAL OF EXISTING STRUCTURES.

A. All existing foundations, pipes, headwalls, manholes, or other structures to be removed shall be disposed of off airport property unless otherwise shown on the plans.

B. Any buildings and miscellaneous structures that are shown on the plans to be removed shall be demolished or removed, and all materials therefrom shall be disposed of by removing them from the site. The remaining or existing foundations, wells, cesspools, and all like structures shall be destroyed by breaking out or breaking down the materials of which the foundations, wells, cesspools, etc., are built to a depth at least 2 feet (60 cm) below the existing surrounding ground. Any broken concrete, blocks, or other objectionable material which cannot be used in backfill shall be removed and disposed of. The holes or openings shall be backfilled with acceptable material and properly compacted.

END OF SECTION 311000
SECTIONS 312000 - EXCAVATION AND EMBANKMENT

PART 1 – DESCRIPTION

1.1 SUMMARY

A. This item shall consist of excavation, disposal, placement, and compaction of all material encountered within the limits of the work not being removed under some other item. This work shall be performed in accordance with the specifications and in conformance with the lines, grades, thickness and typical cross sections shown on the plans, or established by the engineer.

B. Two reports were prepared by Palmerton & Parrish, Inc. dated May 3, 2003, and December 20, 2005, (refer to Appendix B) describing their exploratory drilling of the AVCRAD site and the results of that investigation. Copies of the two reports are also available at the offices of Palmerton & Parrish, Inc.

1.2 CLASSIFICATION.

A. All excavation will be classified as hereafter described.

1. Class A Excavation will consist of all excavation on this project. There will not be any additional payment allowed for the removal of limestone, shale, fire clay, chert, sandstone, igneous rock, or any other material encountered during excavation.

1.3 UNSUITABLE EXCAVATION.

A. Any material containing vegetable or organic matter, such as muck, peat, organic silt, or sod shall be considered unsuitable for use in embankment construction. Material, when approved by the Engineer as suitable to support vegetation, may be used on the embankment slope. The decision of the Engineer is final. The Engineer will be the sole judge regarding unsuitable or suitable soils and material.

1.4 BORROW.

A. Borrow will consist of approved material required for the construction of embankment or for other portions of the work in excess of the quantity of the usable material from required excavations. Borrow material shall be obtained from areas within the limits of the airport property but outside the normal limits of necessary grading, or from areas outside the airport. Borrow will be classified in the same manner as other excavation included in the contract.

PART 2 – CONSTRUCTION METHODS

2.1 GENERAL.

A. Before beginning excavation, grading, and embankment operations in any area, the area shall be completely cleared and grubbed in accordance with Section 02230.

B. The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All waste areas shall be graded to allow positive drainage of the area and of adjacent areas. The surface elevation of waste areas shall not extend above the surface elevation of adjacent usable areas of the airport, unless specified on the plans or approved by the Engineer.
C. When the Contractor’s excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued. At the direction of the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and allow for their removal.

D. Those areas outside of the pavement areas in which the top layer of soil material has become compacted, by hauling or other activities of the Contractor shall be scarified and disked to a depth of 4 inches, in order to loosen and pulverize the soil.

E. If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the Engineer. The Contractor shall, at his/her own expense, satisfactorily repair or pay the cost of all damage to such facilities or structures which may result from any of the Contractor’s operations during the period of the contract. Any relocation of utilities that are required for the proper placement of facilities in this project shall be done at the expense of the Contractor.

2.2 EXCAVATION.

A. No excavation shall be started until the work has been staked out by a Professional Land Surveyor licensed in the State of Missouri at the expense of the Contractor. All suitable excavated material shall be used in the formation of embankment, subgrade, or for other purposes shown on the plans.

B. When the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development or disposed of as directed. When the volume of excavation is not sufficient for constructing the fill to the grades indicated, the deficiency shall be obtained from borrow areas.

C. The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the work.

1. Selective Grading. When selective grading is indicated on the plans, the more suitable material as designated by the Engineer shall be used in constructing the embankment or in capping the pavement subgrade.

2. Undergrading. Limestone, shale, fire clay, chert, sandstone, and igneous rock excavation for runway safety areas, subgrades, roads, shoulders, or any areas intended for turfing shall be excavated to a depth of 12 inches, or to the depth specified by the Engineer, below the subgrade.
   a. Excavating and undergrading in rock shall be performed in a manner to produce material of such size as to permit being placed in embankments in accordance with the requirements of section 02315, sub-section 2.5. Where rock cuts are made and refilled with selected materials, any rock pockets created in the rock surface shall be drained.
   b. Muck, peat, matted roots, loose boulders, or other material, unsatisfactory for subgrade foundation, shall be removed to the depth specified by the Engineer. Unsuitable materials shall be disposed of outside of the airport property. The Contractor shall comply with all requirements of Section 00800, sub-section 5.0.
   c. All undergraded areas shall be refilled with suitable material, obtained from the grading operations or borrow areas and thoroughly compacted as indicated in sub-section 2.5.

3. Overbreak. Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the Engineer. The Engineer shall determine if the displacement of such material was unavoidable and his/her decision shall be final. All overbreak shall be graded and removed by the Contractor and disposed of as directed.
4. Removal of Utilities. The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by someone other than the Contractor at the Contractor’s expense, e.g., the utility unless otherwise shown on the plans. All existing foundations shall be excavated for at least 2 feet below the top of subgrade or as indicated on the plans, and the material disposed of as directed. All foundations thus excavated shall be backfilled with suitable material and compacted as specified herein.

5. Compaction Requirements. The upper 24 inches of all fill under areas for airside paving or under all buildings shall be compacted to a density of not less than 95 percent of the maximum density as determined by ASTM D1557. Fill depths greater than 24 inches below subgrade under airside paving or under all buildings and for all other fill shall be compacted to a density of not less than 90 percent of the maximum density as determined by ASTM D1557. The subgrade of a cut under areas for airside paving or under all buildings shall be scarified and recompacted to a depth of 12 inches and to a density of not less than 95 percent of the maximum density as determined by ASTM D1557. The material to be compacted shall be within +/- 2 percent of optimum moisture content before rolling to obtain the prescribed compaction.

a. There will be no separate measurement of payment for suitable or unsuitable material removed, manipulated, and replaced in order to obtain the required depth of density.

b. The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 2922. Stones or rock fragments larger than 4 inches in their greatest dimension will not be permitted in top 6 inches of the subgrade. The finished grading operations, conforming to the typical cross section, shall be completed and maintained at least 1,000 feet ahead of the paving operations or as directed by the Engineer.

c. In cuts, all loose or protruding rocks on the back slopes shall be barred loose or otherwise removed to line of finished grade of slope. All cut-and-fill slopes shall be uniformly dressed to the slope, cross section, and alignment shown on the plans or as directed by the Engineer.

d. Blasting will not be permitted.

2.3 BORROW.

A. Borrow area(s) within the airport property will be identified by the Engineer. Borrow shall be made only at these designated locations and within the horizontal and vertical limits as staked or as directed. Borrow material shall not be placed until after material from required excavation has been placed in the embankment, except as approved otherwise by the engineer. The Contractor shall comply with all requirements of Section 00800, sub-section 5.0.

B. When borrow sources are outside the boundaries of the airport property, it shall be the Contractor’s responsibility to locate and obtain the supply, subject to the approval of the Engineer. The Contractor shall notify the Engineer, at least 15 days prior to beginning the excavation, so necessary tests can be made. All unsuitable material shall be disposed of by the Contractor. All borrow areas shall be bladed and left in such shape as to permit taking the necessary cross sections after excavating has been completed. The finished borrow areas shall be approximately true to line and grade if so specified in the contract, and shall be finished, where practicable, so that no water will collect or stand therein.

2.4 PREPARATION OF EMBANKMENT AREA.

A. Where an embankment is to be constructed, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 6 inches. This area shall then be compacted as indicated in sub-section 2.5.

B. Where embankments are to be placed on natural slopes steeper than 3 to 1, horizontal benches shall be constructed as shown on the plans.
2.5 FORMATION OF EMBANKMENTS.

A. Embankments shall be formed in successive horizontal layers of not more than 8 inches in loose depth for the full width of the cross section, unless otherwise approved to the Engineer.

B. The grading operations shall be conducted, and the various soil strata shall be placed, to produce a soil structure as shown on the typical cross section or as directed. Materials such as brush, hedge, roots, stumps, grass and other organic matter, shall not be incorporated or buried in the embankment.

C. Operations on earthwork shall be suspended at any time when satisfactory results cannot be obtained because of rain, freezing, or other unsatisfactory conditions of the field. The Contractor shall drag, blade, or slope the embankment to provide proper surface drainage.

D. The material in the layer shall be within +/-2 percent of optimum moisture content before rolling to obtain the prescribed compaction. In order to achieve a uniform moisture content throughout the layer, wetting or drying of the material and manipulation shall be required when necessary. Should the material be too wet to permit proper compaction or rolling, all work on all of the affected portions of the embankment shall be delayed until the material has dried to the required moisture content. Sprinkling of dry material to obtain the proper moisture content shall be done with approved equipment that will sufficiently distribute the water. Sufficient equipment to furnish the required water shall be available at all times. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken for each 1,000 cubic yards. Based on these tests, the Contractor shall make the necessary corrections and adjustments in methods, materials or moisture content in order to achieve the correct embankment density.

E. On all areas outside of the pavement areas, no compaction will be required on the top 4 inches.

F. The in-place field density shall be determined in accordance with ASTM D 1556 or ASTM D 2167 and shall be performed at a frequency of at least 5,000 square feet per lift with a minimum of 3 tests per lift.

G. In lieu of the core method of field density determination, acceptance testing may be accomplished using a nuclear gage in accordance with ASTM D 2922 using the Direct Transmission Method. The nuclear gage shall be calibrated in accordance with Annex A1. Calibration and operation of the gage shall be in accordance with the requirements of the manufacturer. The operator of the nuclear gage must show evidence of training and experience in the use of the instrument. The gage shall be standardized daily in accordance with ASTM D 2922, paragraph 8.

H. Use of ASTM D 2922 results in a wet unit weight, and when using this method, ASTM D 3017 shall be used to determine the moisture content of the material. The moisture gage shall be standardized daily in accordance with ASTM D 3017, paragraph 7.

I. Compaction areas shall be kept separate, and no layer shall be covered by another until the proper density is obtained.

K. During construction of the embankment, the Contractor shall route his/her equipment at all times, both when loaded and when empty, over the layers as they are placed and shall distribute the travel evenly over the entire width of the embankment. The equipment shall be operated in such a manner that hardpan, cemented gravel, clay, or other chunky soil material will be broken up into small particles and become incorporated with the other material in the layer.

L. In the construction of embankments, layer placement shall begin in the deepest portion of the fill; as placement progresses, layers shall be constructed approximately parallel to the finished pavement grade line.
M. When rock and other embankment material are excavated at approximately the same, time, the rock shall be incorporated into the outer portion of the embankment and the other material shall be incorporated under the future paved areas. Stones or fragmentary rock larger than 4 inches in their greatest dimensions will not be allowed in the top 6 inches of the subgrade. Rock fill shall be brought up in layers as specified or as directed and every effort shall be exerted to fill the voids with the finer material forming a dense, compact mass. Rock or boulders shall not be disposed of outside the excavation or embankment areas, except at places and in the manner designated by the Engineer.

N. When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in layers not exceeding 2 feet in thickness. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of rock. These type lifts shall not be constructed above an elevation 4 feet below the finished subgrade. Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with specified methods.

O. Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material.

2.6 FINISHING AND PROTECTION OF SUBGRADE.

A. After the subgrade has been substantially completed the full width shall be conditioned by removing any soft or other unstable material which will not compact properly. The resulting areas and all other low areas, holes or depressions shall be brought to grade with suitable select material. Scarifying, blading, rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the lines and grades shown on the plans.

B. Grading of the subgrade shall be performed so that it will drain readily. The Contractor shall take all precautions necessary to protect the subgrade from damage. He/she shall limit hauling over the finished subgrade to that which is essential for construction purposes.

C. All ruts or rough places that develop in a completed subgrade shall be smoothed and recompacted.

D. No subbase, or surface course shall be placed on the subgrade until the subgrade has been approved by the Engineer.

2.7 HAUL.

A. All hauling will be considered a necessary and incidental part of the work.

2.8 TOLERANCES.

A. In those areas upon which a subbase or base course is to be placed, the top of the subgrade shall be of such smoothness that, when tested with a 16-foot straightedge applied parallel and at right angles to the centerline, it shall not show any deviation in excess of 1/2-inch, or shall not be more than 0.05-foot from true grade as established by grade hubs or pins. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing materials; reshaping; and recompacting by sprinkling and rolling.

B. On runway safety areas, intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 0.10 foot from true grade as established by grade hubs. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.
2.9 **TOPSOIL.**

A. When topsoil is specified or required as shown on the plans or under Section 02919, Topsoiling, it shall be salvaged from stripping or other grading operations. The topsoil shall meet the requirements of Section 02919. If, at the time of excavation or stripping, the topsoil cannot be placed in its proper and final section of finished construction, the material shall be stockpiled at approved locations. Stockpiles shall not be placed within 800 feet of runway pavement or 100 feet of taxiway pavement and shall not be placed on areas which subsequently will require any excavation or embankment. If, in the judgment of the Engineer, it is practical to place the salvaged topsoil at the time of excavation or stripping, the material shall be placed in its final position without stockpiling or further rehandling.

B. Upon completion of grading operations, stockpiled topsoil shall be handled and placed as directed, or as required in Section 02919.

2.10 **BASIS OF PAYMENT.**

A. Payment for earthwork to the grades established on the plans and in these specifications shall be included by the Contractor as a portion of the overall lump sum bid.

B. Excavations resulting from removal of unsuitable soil shall be filled in accordance with paragraph 2.2.C.2.c. The cost of this fill material compacted in place shall be included in the overall lump sum bid.

C. It shall be the responsibility and expense of the Contractor to provide to the Owner “As-Constructed” survey drawings showing all installations, grades, improvements, and all other changes resulting from the Contractor’s activities on this project. These “As-Constructed” survey drawings shall bear the seal, signature and date of a Professional Land Surveyor registered in the State of Missouri. The accuracy and completeness of the field survey for the “As-Constructed” drawings shall be sufficient to produce an accurate topographic map with 1-foot contours at a scale of 1” = 100’.

D. All testing shall be performed by a testing agency approved by the Engineer and at the expense of the Contractor.

END OF SECTION 312000
SECTION 312319 – DEWATERING

PART 1 – DESCRIPTION

1.1 GENERAL

A. The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and ground water entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, or the pipe to be installed, is completed to the extent that no damage from hydrostatic pressure, flotation or other cause will result.

B. All excavation for concrete structures, handholes or trenches which extend down to or below ground water shall be dewatered by lowering and keeping the ground water level at or beneath the bottom of the excavation.

C. Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches to the greatest extent practicable without causing damage to adjacent property.

D. The Contractor will be held responsible for the condition of any pipe or conduit which he may use for drainage purposes, and all such pipes or conduits shall be left clean and free of sediment.

E. The Contractor shall comply with the requirements of these specifications concerning erosion, pollution and sedimentation control.

END OF SECTION 312319
SECTION 312500 - EROSION AND SEDIMENT CONTROL

PART 1 – DESCRIPTION

1.1 SUMMARY

A. This work shall consist of furnishing, installing, maintaining and removing temporary erosion and sediment control measures; furnishing and placing permanent erosion control features; or a combination of both as shown on the plans or as designated by the engineer. This work shall consist of controlling water pollution in accordance with these specifications.

B. The contractor shall exercise best management practices throughout the life of the project to control water pollution. Pollutants such as chemicals, fuels, lubricants, bitumen, raw sewage or other harmful material shall not be discharged from the project. Temporary pollution control measures shall be coordinated with permanent erosion control features specified in the contract to ensure economical, effective and continuous erosion control.

C. Temporary control may include work outside the construction limits such as borrow pit operations, equipment and material storage sites, waste areas, and temporary plant sites.

PART 2 – MATERIALS

2.1 MATERIALS.

A. All materials shall conform to the following requirements:

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<tr>
<th>Item</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Fertilizer</td>
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<td>Seed</td>
<td>Section 02923</td>
</tr>
<tr>
<td>Mulching</td>
<td>Section 02915</td>
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</table>

B. Geotextile Fabric shall meet the physical and chemical requirements of AASHTO M 288.

PART 3 – CONSTRUCTION REQUIREMENTS

3.1 GENERAL.

A. In the event of conflict between these requirements and the pollution control laws, rules or regulations of other federal, state or local agencies, the more restrictive laws, rules or regulations shall apply.

3.2 SCHEDULE OF WORK.

A. Prior to the start of construction, the contractor shall submit schedules for accomplishment of temporary and permanent erosion control work, as are applicable for clearing and grubbing, grading, construction, paving, and structures at watercourses. The contractor shall also submit a proposed method of erosion and dust control on haul roads and borrow pits and a plan for
disposal of waste materials. Work shall not be started until the erosion control schedules and methods of operation for the applicable construction have been accepted by the engineer.

3.3 AUTHORITY OF ENGINEER.

A. The engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, to limit the surface area of erodible earth material exposed by excavation, borrow and fill operations, and to direct the contractor to provide immediate permanent or temporary pollution control measures to minimize contamination of adjacent streams or other watercourses, lakes, ponds, or other areas of water impoundment.

3.4 CONSTRUCTION DETAILS.

A. The contractor will be required to incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in the accepted schedule. Except where future construction operations will damage slopes, the contractor shall perform the permanent seeding and mulching and other specified slope protection work in stages, as soon as substantial areas of exposed slopes can be made available. Temporary erosion and pollution control measures will be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

B. Clearing and grubbing operations shall be scheduled and performed so grading operations and erosion control features will follow immediately thereafter. The surface area of erodible earth material exposed at one time by clearing and grubbing, excavating fill or borrow shall not exceed 435,000 square feet within any individual drainage area without installation of erosion controls for that drainage area. The total erodible surface area exposed at one time for the entire project shall not exceed 750,000 square feet.

C. The engineer will limit the area of clearing and grubbing, excavation, borrow, and embankment operations in progress, commensurate with the contractor’s capability and progress in keeping the finish grading, mulching, seeding, and other such permanent control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

D. In the event that temporary erosion and pollution control measures are required due to the contractor’s negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled or are ordered by the engineer, such work shall be performed by the contractor at his/her own expense.

E. The contractor shall acceptably maintain the erosion control features installed by the contractor during the construction period.

F. Whenever construction equipment must cross watercourses at frequent intervals, and such crossings will adversely affect the sediment levels, temporary structures should be provided.
PART 4 – TEMPORARY EROSION CONTROL
(SILT FENCE/STRAW BALES/SILT SOCK)

4.1 DESCRIPTION.

A. This work shall consist of furnishing, installing, maintaining and removing erosion controls for temporary ditch checks and at other temporary locations shown on the plans for controlling pollution and erosion, and removing sediment deposits at these locations and disposing of the sediment deposits at a location approved by the engineer. The quantities of temporary erosion control shown on the plans may be increased or decreased at the direction of the engineer. At the engineer’s discretion, the location may be field modified to fit field conditions. Such variations in quantity will not be considered as alterations in the details of construction or a change in the character of the work.

4.2 MATERIAL.

A. Geotextile Fabric shall meet the physical and chemical requirements of AASHTO M 288.

B. Posts for silt fence may be wood, steel or synthetic. Posts shall be sufficient length, not less than 4 feet, to ensure adequate embedment while fully supporting the silt fence and shall have sufficient strength to resist damage during installation and to support applied loads while in service.

C. All geotextile silt fence shall be supported either externally by wire or other approved mesh to a height of at least 24 inches or by a suitable designed-in support system capable of keeping the material erect. Either method shall be strong enough to withstand applied loads.

D. Prefabricated fence systems may be used provided they meet all of the above requirements.

E. Posts for straw bales shall be wood. Posts shall be 2-inch by 2-inch and sufficient length, not less than 3 feet, to ensure adequate embedment.

F. Silt sock shall have continuous tubular knitted mesh netting containing composted organic materials designed to trap sediment and filter water passing through.

4.3 CONSTRUCTION REQUIREMENTS.

A. The contractor shall install the temporary erosion control as shown on the plans or at other locations as directed by the engineer. Silt fence construction shall be adequate to handle the stress from hydraulic and sediment loading. Fabric at the bottom of the silt fence shall be buried a minimum 6 inches so that no flow can pass under the barrier. The trench shall be backfilled and the soil compacted over the fabric. The fabric shall be spliced together only at a support post with a minimum 6-inch overlap. Any installation method acceptable to the engineer will be allowed as long as the effectiveness and intent of the silt fence is achieved.

B. Post spacing shall not exceed 5 feet. Posts shall be driven a sufficient depth into the ground or placed on closer spacing as necessary to ensure adequate resistance to applied loads.

C. The silt fence shall be fastened securely to the upslope side of the post. When wire support is used, the wire shall extend into the trench a minimum of 2 inches.
D. Straw bale construction shall be adequate to handle the stress from hydraulic and sediment loading. Geotextile fabric shall be fastened securely to the bale on the side of flow and on top and then embedded a minimum of 6 inches so that no flow can pass under the barrier.

E. Post spacing shall not exceed 2 feet. Posts shall be driven a sufficient depth into the ground or placed on closer spacing as necessary to ensure adequate resistance to applied loads.

F. Construct silt sock according to the manufacturer’s installation requirements.

G. The contractor shall maintain the integrity of the erosion control as long as they are necessary to contain sediment runoff. The contractor shall inspect all erosion control immediately after each rainfall and at least daily during prolonged rainfall. Any deficiencies shall be immediately corrected by the contractor. In addition, the contractor shall make a daily review of the location of erosion control in areas where construction activities have changed the natural contour and drainage runoff to ensure the erosion control is properly located for effectiveness. Where deficiencies exist, additional erosion control shall be installed as approved or directed by the engineer.

H. The contractor shall remove and dispose of sediment deposits when the deposit approaches one-half the height of the original height or sooner when directed by the engineer. Periodic sediment removal shall include removal and disposal of sediment in a location where it will not erode into construction areas or watercourses.

I. The erosion control shall remain in place until the engineer directs it to be removed. Upon removal, the contractor shall remove and dispose of any excess silt accumulations, grade and dress the area to the satisfaction of the engineer, and establish vegetation on all bare areas in accordance with the contract requirements. The erosion control material shall remain the property of the contractor and may be used at other locations, provided the material continues to meet the requirements of this specification, is sound and not weakened by exposure to the elements.

PART 5 – TEMPORARY BERMS

5.1 DESCRIPTION.

A. This work shall consist of constructing temporary berms of compacted soil at the top of fill slopes or transverse to centerline on fills.

5.2 MATERIAL.

A. Temporary berms shall consist of graded material from the site or any suitable material approved by the engineer.

5.3 CONSTRUCTION REQUIREMENTS.

A. Type B berms shall be constructed to the approximate dimensions as shown on the plans. These berms shall be machine compacted with a minimum of three passes over the entire width of the berm. Material removed from Type B berms shall be incorporated in the embankment when possible. The contractor shall dispose any excess or unsuitable material to a location as directed by the engineer.

B. Temporary berms shall drain to a compacted outlet at a slope drain. On transverse berms, the top width of the berms may be wider and the side slopes flatter to allow equipment to pass over these berms with a minimal disruption.
PART 6 – TEMPORARY SLOPE DRAINS

6.1 DESCRIPTION.
   A. This work shall consist of constructing temporary slope drains to carry water down slopes and to reduce erosion. The method selected shall be approved by the engineer prior to construction.

6.2 MATERIAL.
   A. Temporary slope drains shall consist of a temporary facility of stone, concrete, or asphalt gutters, half-round pipe, metal pipe, plastic pipe or flexible rubber pipe.

6.3 CONSTRUCTION REQUIREMENTS.
   A. The contractor shall provide temporary slope drains to carry water or water with suspended solids from cut sections down fill slopes until permanent facilities are installed. The contractor shall provide temporary slope drains on fill slopes at approximately 500-foot intervals or as directed by the engineer. All temporary slope drains shall be adequately anchored to the slope to prevent disruption of flow. The inlet end shall be properly constructed to channel water into the temporary slope drain. The outlet ends of these temporary slope drains shall have some means of dissipating the energy of the water to reduce erosion downstream. Unless otherwise specified by the engineer, all temporary slope drains shall be removed by the contractor after permanent facilities are installed. The contractor shall restore the site to match the surroundings.

PART 7 – SEDIMENT BASINS

7.1 DESCRIPTION.
   A. This work shall consist of constructing sediment basins as shown on the plans or as determined by the engineer to trap and store sediments that occur in spite of temporary erosion control measures in use.

7.2 CONSTRUCTION REQUIREMENTS.
   A. The area where a sediment basin is to be constructed shall be cleared of all vegetation to enable removal of sediment. The sediment basin shall be an excavated or dammed storage area with rock riprap placed in inlet and outlet areas with defined slopes.

   B. The inlet of a sediment basin shall be constructed with a wide cross-section and a minimum grade to prevent turbulence and to allow deposition of soil particles. When the depth of sediment reaches 1/3 of the structure’s depth in any part of the pool, all accumulations shall be removed.

   C. Sediment basins shall remain in service until all disturbed areas draining into the structure have been satisfactorily stabilized. When use of a temporary sediment basin is to be discontinued, all excavations shall be backfilled and properly compacted. The contractor shall remove any sediment material and shall restore the existing ground to its natural or intended condition. The contractor shall dispose both accumulated sediment and excavated material removed during construction of the sediment basin in locations that the sediment will not again erode into the construction areas or into natural waterways.
TEMPORARY SEEDING AND MULCHING

8.1 DESCRIPTION.

A. This work shall consist of fertilizing, furnishing and sowing of seed, mulching or other acceptable cover authorized by the engineer. This work shall produce a quick ground cover to reduce erosion in disturbed areas expected to be redisturbed at a later date. Finish grading of areas will not be required. Hydraulic seeding and fertilizing in accordance with Section 02923 will be allowed.

8.2 CONSTRUCTION REQUIREMENTS.

A. Seeding and mulching shall be a continuous operation on all cut and fill slopes, excess material sites and borrow pits during the construction process. All disturbed areas shall be seeded and mulched as necessary to eliminate erosion. The contractor shall provide permanent seeding and mulching as shown on the plans following temporary seeding.

B. Temporary seeding mixtures of oats, cereal rye or wheat shall be applied at a rate of 100 pounds per acre. Temporary seeding mixtures of oats shall be applied only during the months of December through May.

C. Temporary mulch placed over temporary seed mixtures shall be applied in accordance with Section 02915.

D. Fertilizer shall be applied at a rate of 40 pounds nitrogen per acre. Lime will not be required for temporary seeding.

END OF SECTION 312500
SECTION 321123 - CRUSHED AGGREGATE BASE COURSE

PART 1 – DESCRIPTION

1.1 SUMMARY

A. This work shall consist of furnishing and placing one or more courses of crushed aggregate base on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans. Aggregate base shall meet the requirements of the current edition of the Missouri Standard Specification for Highway Construction (MSSHc), Section 304 - Aggregate Base Course. All construction methods, testing, and acceptance criteria shall be in accordance with the standards included within this section.

PART 2 – MATERIALS

2.1 AGGREGATE

A. All materials for aggregate base shall conform to the requirements of the current edition of the MSSHC, Section 304, for Type 5 Aggregate.

B. The ledge stone from which the aggregate base will be produced has to have source approval from the Missouri Department of Transportation (MoDOT). Prior to use of materials, the contractor shall submit the current MoDOT source approval letter to the Engineer for the materials proposed for use during construction. Source approval granted for “all types of highway construction” (Product Code 1005CACP) constitutes approval for all uses. Source approval granted for “all types except PCCP” (Product Code 1005CACM) comprises approval for all uses except portland cement concrete pavement. Source approval obtained for “all types except PCCP & PCCM” (Product Code 1002CAAC) is considered to be approval for all uses except portland cement concrete.

C. The contractor shall submit certified test reports to the Engineer for the gradation of the aggregate base. The certification shall show the appropriate AASHTO test for the material, the test results, and a statement that the material passed or failed. The aggregate shall be sampled and tested for gradation using the following procedures:

1. Sampling Aggregates. Sampling shall be in accordance with AASHTO T 2.
2. Sieve Analysis of Fine and Coarse Aggregate. The aggregate shall be tested in accordance with AASHTO T 27 and shall meet the gradation requirements of the MSSHC, Section 1007.
3. Material Passing No. 200 Sieve. The aggregate shall be tested in accordance with AASHTO T 11 and meet the requirements of the MSSHC, Section 1007.

D. In lieu of the above gradation testing requirements, the contractor may provide documentation from MoDOT (District Materials Office) indicating that the material meets specification requirements.

E. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.
PART 3 – CONSTRUCTION METHODS

3.1 PREPARING UNDERLYING COURSE

A. The underlying course shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause shall be corrected at the Contractor's expense before the base course is placed thereon. Material shall not be placed on frozen subgrade.

3.2 MIXING

A. The aggregate shall be uniformly blended during crushing operations or mixed in a plant. The plant shall blend and mix the materials to meet the specifications and to secure the proper moisture content for compaction.

3.3 PLACING

A. The crushed aggregate base material shall be placed on the moistened subgrade in layers of uniform thickness with a mechanical spreader. The maximum depth of a compacted layer shall be 6 inches. If the total depth of the compacted material is more than 6 inches, it shall be constructed in two or more layers. In multi-layer construction, the base course shall be placed in approximately equal-depth layers.

B. The previously constructed layer should be cleaned of loose and foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered with the next layer.

3.4 COMPACTION

A. Immediately upon completion of the spreading operations, the crushed aggregate shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.

B. The moisture content of the material during placing operations shall not be below, nor more than 1-1/2 percentage points above, the optimum moisture content as determined by ASTM D 1557.

3.5 ACCEPTANCE SAMPLING AND TESTING FOR DENSITY

A. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day's production where it is not expected to exceed 2400 square yards. A lot will consist of one-half day's production where a day's production is expected to consist of between 2400 and 4800 square yards.

B. Each lot shall be divided into two equal sublots. One test shall be made for each sublot by a testing laboratory employed by the Contractor and acceptable to the Engineer. Sampling locations will be determined by the Engineer on a random basis in accordance with statistical procedures contained in ASTM D 3665.

C. Each lot will be accepted for density when the field density is at least 100 percent of the maximum density of laboratory specimens prepared from samples of the base course material.
delivered to the job site. The specimens shall be compacted and tested in accordance with ASTM D 1557. The in-place field density shall be determined in accordance with ASTM D 1556 or D 2167. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached.

D. In lieu of the core method of field density determination, acceptance testing may be accomplished using a nuclear gage in accordance with ASTM D 2922 using the Direct Transmission Method. The nuclear gage shall be calibrated in accordance with Annex A1. Calibration and operation of the gage shall be in accordance with the requirements of the manufacturer. The operator of the nuclear gage must show evidence of training and experience in the use of the instrument. The gage shall be standardized daily in accordance with ASTM D 2922, paragraph 8.

E. Use of ASTM D 2922 results in a wet unit weight, and when using this method, ASTM D 3017 shall be used to determine the moisture content of the material. The moisture gage shall be standardized daily in accordance with ASTM D 3017, paragraph 7.

F. If a nuclear gage is used for density determination, two random readings shall be made for each sublot.

3.6 FINISHING

A. The surface of the aggregate base course shall be finished by blading or with automated equipment especially designed for this purpose.

B. In no case will the addition of thin layers of material be added to the top layer of base course to meet grade. If the elevation of the top layer is 1/2 inch or more below grade, the top layer of base shall be scarified to a depth of at least 3 inches, new material added, and the layer shall be blended and recompacted to bring it to grade. If the finished surface is above plan grade, it shall be cut back to grade and rerolled.

C. Type 5 aggregate base is intended to provide some drainage and shall not be segregated. Trimmed Type 5 aggregate base may not be reused until it is verified as meeting the required specifications. Base material contaminated to such an extent that it no longer complies with the specifications shall be removed and replaced with satisfactory material at the expense of the contractor.

3.7 SURFACE TOLERANCES.

A. The finished surface shall not vary more than 3/8 inch when tested with a 16-foot straightedge applied parallel with or at right angles to the centerline. Any deviation in excess of this amount shall be corrected by the Contractor at the Contractor's expense.

3.8 THICKNESS CONTROL.

A. The completed thickness of the base course shall be within 1/2 inch of the design thickness. Four determinations of thickness shall be made for each lot of material placed. The lot size shall be consistent with that specified in paragraph 3.5. Each lot shall be divided into four equal sublots. One test shall be made for each sublot. Sampling locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Where the thickness is deficient by more than 1/2 inch, the Contractor shall correct such areas at no additional cost by excavating to the required depth and replacing with new material. Additional
test holes may be required to identify the limits of deficient areas.

3.9 MAINTENANCE.

A. The base course shall be maintained in a condition that will meet all specification requirements until the work is accepted. Equipment used in the construction of adjoining sections may be routed over completed portions of the base course, provided no damage results and provided that the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

B. If a prime coat is specified in the contract, the contractor will be required to apply the prime coat on any completed portion of the aggregate base as soon as practicable, or as otherwise specified. However, the contractor will not be permitted to apply prime if the moisture in the top 2 inches of the aggregate base exceeds the higher of either (1) the average of the optimum moisture as determined by the standard compaction test and the absorption of the plus No. 4 fraction, or (2) two-thirds of the optimum moisture as determined by the standard compaction test.

C. At the discretion of the engineer, proof rolling may be required by a loaded tandem axle truck on top of the aggregate base course to determine the level of stability. If the condition of the aggregate base course is not satisfactory, it should be given more time to cure or be reworked to put it into the proper condition for overlay.

END OF SECTION 321123
SECTION 321216 – HOT-MIX ASPHALT PAVING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Comply with the requirements of City of Springfield, Missouri, Technical Specifications for Public Improvements included in Appendix D.

1.2 SUMMARY

A. This section includes the following:

1. Plant mix bituminous base course.

2. Plant mix bituminous surface course.

END OF SECTION 321216
SECTION 321313 - CEMENT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Comply with the requirements of City of Springfield, Missouri, Technical Specifications for Public Improvements, included in Appendix D.

1.2 SUMMARY

A. This Section includes exterior cement concrete pavement for the following:

1. Curbs and gutters.
2. Sidewalks.
3. Mow curb.
5. Thrust Blocking, Fence Post, Equipment Pad, etc.

1.3 SUBMITTALS

A. Design Mixes: For each concrete pavement mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

END OF SECTION 321313
SECTION 321723 – PAVEMENT MARKINGS (PARKING LOT)

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and General Conditions of the Contract.
   B. Comply with the requirements of Missouri Standard Specifications for Highway Construction, latest edition, Section 620.

1.2 SUMMARY
   A. This section includes the following:
      1. Pavement markings for parking spaces, and related uses.

1.3 GENERAL REQUIREMENTS
   A. STRIPING PAINT: Paint for parking stalls and all other striping shall be white latex traffic paint complying with Federal Specifications (FS) TT-P-1952.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 321723
SECTION 329200 - TOPSOILING

PART 1 – DESCRIPTION

1.1 SUMMARY

A. This item shall consist of removing topsoil from areas to be stripped on the project site, preparing the ground surface for topsoil application, and placing and spreading the topsoil on prepared areas in accordance with this specification at the locations shown on the plans or as directed by the Engineer.

PART 2 – MATERIALS

2.1 TOPSOIL.

A. Topsoil shall be a fertile, friable and loamy soil of uniform quality, without admixture of subsoil material, and shall be free from material such as hard clods, stiff clay, hardpan, partially disintegrated stone, pebbles larger than 2 inches in diameter and any other similar impurities. Topsoil shall be relatively free from grass, roots, weeds and other objectionable plant material or vegetative debris undesirable or harmful to plant life or which will prevent the formation of a suitable seedbed.

PART 3 – CONSTRUCTION METHODS

3.1 GENERAL.

A. The areas to be stripped of topsoil and the stripping depths shall be shown on the plans. Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping of topsoil, and for handling and placing of all required materials shall be on hand, in good condition, and approved by the Engineer before the various operations are started.

3.2 OBTAINING TOPSOIL.

A. Prior to the stripping of topsoil from designated areas, any vegetation, briars, stumps and large roots, rubbish or stones found on such areas, which may interfere with subsequent operations, shall be removed using methods approved by the Engineer. Heavy sod or other cover, which cannot be incorporated into the topsoil by discing or other means, shall be removed.

B. The contractor shall remove all suitable topsoil from the designated areas on the project site and to the depth as directed by the Engineer. The topsoil shall be spread on areas already tilled and smooth-graded or stockpiled in areas approved by the Engineer. There will not be a unit price for topsoil. All topsoil obtained on the site shall be used onsite. Topsoil will not be allowed to be taken offsite. If topsoil is required to be brought on site, then follow instruction in Section 00800.
3.3 PREPARING THE GROUND SURFACE

A. Immediately prior to placing and spreading the topsoil on any area, the surface shall be loosened by discs or spike-tooth harrows, or by other means approved by the Engineer, to a minimum depth of 2 inches to facilitate bonding of the topsoil to the covered subgrade soil. The surface of the area to be topsoiled shall be cleared of all stones larger than 2 inches in any diameter and all litter or other material which may be detrimental to proper bonding, the rise of capillary moisture, or the proper growth of the desired planting. Limited areas, as shown on the plans, which are too compact to respond to these operations shall receive special scarification.

B. Grades on the area to be topsoiled, which have been established by others as shown on the plans, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth graded and the surface left at the prescribed grades in an even and properly compacted condition to prevent, insofar as practical, the formation of low places or pockets where water will stand.

3.4 PLACING TOPSOIL

A. The topsoil shall be evenly spread on the prepared areas to a uniform depth of 3 inches after compaction, unless otherwise shown on the plans or stated in the Special Provisions. Spreading shall not be done when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to the work. Spreading shall be carried on so that turfing operations can proceed with a minimum of soil preparation or tilling.

B. After spreading, any large, stiff clods and hard lumps shall be broken with a pulverizer or by other effective means, and all stones or rocks (2 inches or more in diameter), roots, litter, or any foreign matter shall be raked up and disposed of by the Contractor. After spreading is completed, the topsoil shall be satisfactorily compacted by rolling with a cultipacker or by other means approved by the Engineer. The compacted topsoil surface shall conform to the required lines, grades, and cross sections. Any topsoil or other dirt falling upon pavements as a result of hauling or handling of topsoil shall be promptly removed.

END OF SECTION 329200
SECTION 329210 - TURF SODDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Requirements of the Contract, including Special Conditions and Division 1 Specifications that apply to this Section.

1.2 SUMMARY

A. This Section includes provision and placement of topsoil and soil amendments; furnishing and installing sodded lawn areas. Substantial completion date for site work may vary from that of the building substantial completion date.

1.3 RELATED DOCUMENTS

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

1.4 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

C. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.

1.5 SUBMITTALS

A. Product data and/or Certificates of Conformance or compliance: Before delivery, notarized certificates attesting that the following materials meet the requirements specified shall be submitted to the Engineer for approval:

1. Fertilizers
2. Lime
3. Peat
4. Sod
5. Herbicide

B. Materials Qualification Test: Submittal prepared by independent testing lab to indicate that proposed material complies with contract document requirements.

1. Provide following qualification tests and information for topsoil regardless if imported or prepared from select on-site material.
2. Mechanical gradation analysis, ASTM D422.
3. Topsoil testing performed by state university soils science department, soils testing laboratory, or other recognized soil physics testing laboratory with recommendation for type and application rate of amendments needed to adjust topsoil to required nutrient levels for each proposed landscape operation, i.e., seeding, sodding, ground covers, etc.

1.6 QUALITY ASSURANCE

A. Pre-installation Conference: Contractor, seeding contractor, Engineer and Owner Representatives, and representatives of other affected trades must meet at Site to review soil preparation, seeding and maintenance procedures a minimum of 1 week prior to start of topsoil preparation and seeding operations.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Sod: Harvest, deliver, store, and handle sod according to requirements in American Sod Producers Association, Inc. (ASPA) “Specifications for Turfgrass Sod Materials” and “Specifications for Turfgrass Sod Transplanting and Installation” in its “Guideline Specifications to Turfgrass Sodding.” During delivery protect sod from drying out. Sprinkle sod with water and cover with moist burlap, straw or other approved covering to protect from exposure to wind and direct sunlight. Covering should permit air circulation to alleviate heat development. Sod shall be rolled or folded prior to lifting. Handling of sod shall be performed in a manner that will prevent tearing, breaking, drying and other damage. Do not deliver more sod than can be laid within 24 hours. Sod damaged by heat or dry conditions shall not be used.

1.8 WATERING & MAINTENANCE

A. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Sodded Lawns: 60 days after the date of Substantial Completion.

B. Water sod regularly to maintain an adequate supply of moisture penetration through sod into top 6 inches of topsoil. Adequate moisture supply during Fall and Spring planting dates is the equivalent of one inch of absorbed water per week either through natural rainfall or augmented by periodic waterings. Apply water at a moderate rate so as not to displace the mulch or flood the turf areas. Adequate moisture should be divided into two to three waterings per week, as directed by the Owner’s Representative. During the summer (June 2 through August 31) watering may be required on a daily basis, as directed by the Owner’s Representative. During the winter months confer with the Owner’s Representative regarding the frequency of watering.

C. The maintenance period shall extend as required until final acceptance by the Owner’s Representative for substantial completion. See Sections 1.8 and 3.4 for general acceptance criteria.
PART 2 - PRODUCTS

2.1 TURFGRASS SOD

A. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with TPI’s “Specifications for Turfgrass Sod Materials” in its “Guideline Specifications to Turfgrass Sodding.” Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Turfgrass Species: Turf type tall fescue mix, including blend of 4 turf type tall fescue cultivators and Kentucky blue grass, 1-inch minimum soil thickness, no netting. The measurement for thickness shall exclude top growth and thatch.

C. Wood Pegs: Shall be made of soft wood; sufficient size and length to ensure anchorage.

2.2 PLANTING MATERIALS

A. Topsoil shall be a well-graded soil of good uniform quality. It shall be a natural, friable soil representative of productive soils in the vicinity. Topsoil shall be free of admixture of subsoil, foreign matter, objects larger than one inch in any dimension, toxic substances, weeds and any material or substances that may be harmful to plant growth and shall have a pH value of not less than 5.0 nor more than 7.5. The Contractor shall submit an analysis of soils along with samples for approval by the Landscape Architect.

B. Material to be obtained from stockpiles, if any, established under Section SITE CLEARING, subparagraph, Stripping Topsoil, and shall meet the general requirements as stated above. Topsoil not meeting the pH range specified shall be amended by the addition of pH Adjusters.

PART 3 - EXECUTION

3.1 SOIL MODIFICATIONS

A. Subsoil Preparation:

1. Till compacted soils to a depth of 8 inches minimum.
2. Remove all buried rocks and debris that is larger than 1” in any direction. Contractor shall utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (eg. sticks, roots, trash and other extraneous matter).

B. Topsoil Preparation:

1. Weed Control: Apply “Round-up”, “Ortho Weed-B-Gon” or “Spectracide Triple Strike” to heavily weeded areas at least one week prior to working the soil. Owner’s Representative shall be notified 48 hours in advance to be present to view and approve product and application on site.
2. Remove all buried rocks and debris that is larger than 1” in any direction. Contractor shall utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (eg. sticks, roots, trash and other extraneous matter).
3. Amendments: Test topsoil for fertility and apply amendments as required, with the following general guidelines:
   a. Add 1-2 pounds each of Nitrogen, Phosphorous, and Potassium per 1000 square feet.
   b. Till the fertilizer into the top 3-4 inches of topsoil immediately after application.
   c. Owner’s Representative shall be notified to be 48 hours in advance to be present to view and approve products and application on site.

3.2 LAWN PREPARATION

A. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 8 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter, and legally dispose of them off Owner’s property.
   1. Spread planting soil mix to a minimum depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
   2. Blend a portion of topsoil with the top 2-3 inches of subsoil.

B. Unchanged Subgrades:
   1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
   2. Loosen surface soil to a depth of at least 6 inches. Till soil to a homogeneous mixture of fine texture.
   3. Remove all buried rocks and debris that is larger than 1” in any direction. Contractor shall utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (eg. sticks, roots, trash and other extraneous matter).
   4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner’s property.

C. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus ½ inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.

D. Final Soil Preparation: Prepare soil not less than 24 hours prior to planting.
   1. Rake soil surfaces to completely scarify subsoil to a depth of 2 inches and remove solid crust no more than one day prior to laying sod.
   2. Clods should be broken down to 1-5 mm, and then rolled until firm.
   3. Level any uneven areas.

E. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Restore areas if eroded or otherwise disturbed after finish grading and before planting.
3.3 SODDING

A. Install Sod within the following dates: From March 15 to June 1 for spring and from September 1 to November 1 for fall.

B. Laying of Sod:

1. Lay sod during growing season and within 48 hours of being lifted.
2. Lay sod while top 6 inches (150mm) of soil is damp, but not muddy. Sodding during freezing temperatures or over frozen soil is not acceptable.
3. Lay sod in rows perpendicular to slope with joints staggered. Butt sections closely without overlapping or leaving gaps between sections. Cut out irregular or thin sections with a sharp knife.
4. Lay sod flush with adjoining existing sodded surfaces.
5. Sod slopes steeper than 3:1: Pin each piece of sod at both uphill corners. Stake should be vertical (not perpendicular to the ground surface).

C. After Laying of Sod is Complete:

1. Roll horizontal surface areas in two directions perpendicular to each other.
2. Repair and re-roll areas with depressions, lumps, or other irregularities. Heavy rolling to correct irregularities in grade will not be permitted.
3. Water sodded areas immediately after laying sod to obtain moisture penetration through sod into top 6 inches (150mm) of topsoil.
4. Watering and maintenance shall comply with subsections 1.8 and 3.4.

3.4 SATISFACTORY LAWNS

A. Field Inspection:

1. Sodded areas will be accepted at Substantial Completion if:
   a. Sodded areas are properly established such that within any 10’ x 10’ area of turf there is less than 5% weed coverage; sod is free of bare and dead spots and is without weeds; and no surface soil is visible when grass has been cut to height of 2-1/2 inches.
2. Sodded areas have been mowed a minimum of twice.
   a. At time of first cutting, mower blades shall be set to produce a 2-1/2 inch mowed height.

B. Maintain lawn areas from completion of installation to 60 days after substantial completion of site work. Areas installed after November 1 will be reviewed for acceptance the following spring approximately one month after start of growing season. Maintenance may include fertilize and weed killers, as necessary, to achieve a weed free satisfactory lawn.

C. Re-sod areas that do not comply with requirements until areas are satisfactory. Replaced lawn areas shall be guaranteed and maintained by the Contractor for an additional 30 days from date of replacement.

D. Remove sod pins/and or stakes once sod is firmly rooted.

E. Mowing
1. **Beginning at Acceptance of the Landscape Installation (site work substantial completion) and continuing for a 60-day period, mow entire project limits once each seven (7) days with no less than five (5) days between mowing.**

2. **Trash and litter shall be removed from area to be mown prior to mowing and taken off-site, if no public trash containers are available.**

3. **All mowing equipment shall be equipped with sharp blades that do not tear the grass but cleanly cut the grass.**

4. **All grass shall be mowed to two-third of its pre-cut height and to a maximum height of three inches.**

5. **All sidewalks, curbs, and steps shall be mechanically trimmed. Chemical edging by Contractor shall not be permitted.**

6. **All structures, trees, poles, signs, fences, walls and shrub beds are to be trimmed closely. Trimming shall be accomplished concurrently with mowing.**

7. **The mowed area shall be free of clumped grass and not show tire tracks or ruts from mowing equipment.**

8. **Mowing shall not discharge grass clippings onto paved areas or other improved areas. Any materials from mowing operations blown or discharged on to such areas shall be removed immediately.**

9. **Grass clippings may be finely cut by use of a mulching-type mower. Removal of clippings from turf areas will not be required, if clippings are mulched in such manner.**

10. **Mowing or trimming operations shall not damage plants or other improvements.**

**END OF SECTION 329210**
SECTION 329220 – TURF SEEDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes furnishing all labor, equipment, and materials necessary for the preparation, fertilization, seeding, and mulching of the site as shown on plans. All disturbed areas shall be seeded and mulched, except for surfaced areas, and solid rock. Disturbed areas outside the authorized construction limits shall be seeded and mulched at the Contractor’s expense. **Substantial completion date for site work may vary from that of the building substantial completion date.**

1.3 SUBMITTALS

A. Comply with requirements of the General Conditions, Article 3.2; and this Section.

B. Responsibility for arranging, supervising and payment for required tests listed below are indicated in Project Manual or Conditions of the Contract.

C. Submit material qualification tests, and other noted items directly from testing laboratory.

D. Following Submittals are required for portions of Work specified in this Section:

1. Product data and/or Certificates of Conformance or Compliance: Before delivery, notarized certificates attesting that the following materials meet the requirements specified shall be submitted to the Engineer for approval:
   a. Fertilizers
   b. Lime
   c. Peat
   d. Seed
   e. Herbicide

2. Materials Qualification Test: Submittal prepared by independent testing lab to indicate that proposed material complies with contract document requirements.
   a. Provide following qualification tests and information for topsoil regardless if imported or prepared from select on-site material.
   b. Mechanical gradation analysis, ASTM D422.
   c. Topsoil testing performed by state university soils science department, soils testing laboratory, or other recognized soil physics testing laboratory with recommendation for type and application rate of amendments needed to adjust topsoil to required nutrient levels for each proposed landscape operation, i.e., seeding, sodding, ground covers, etc.
1.4 QUALITY ASSURANCE

A. Pre-installation Conference: Contractor, seeding contractor, Engineer and Owner Representatives, and representatives of other affected trades must meet at Site to review soil preparation, seeding and maintenance procedures a minimum of 1 week prior to start of topsoil preparation and seeding operations.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver fertilizer, seed, and other packaged commercial products in original unopened containers bearing manufacturer’s guaranteed chemical analysis, name, tradename and trademark, and in conformance with applicable laws.

1. Project Conditions

1.1 Store products in accord with manufacturer’s instructions.

2. Protect fertilizer, seed and other packaged products from heat, moisture, rodents and damage from other causes.

3. Do not expose products to weather prior to and after delivery until used.

4. Do not store products in direct contact with ground.

5. During delivery protect seed from contamination.

1.6 PROJECT CONDITIONS

A. Environmental Requirements: Conduct operations only under specified weather conditions and only during specified seeding seasons.

1.7 SEQUENCING/SCHEDULING

A. Seed indicated areas during first specified planting season following completion of permanent construction in seeded areas, final grading and topsoil placement.

B. Turf Grass Planting Seasons:

1. Fall Planting: September 1 – November 1

2. Spring Planting: March 15 – June 1

C. Final grading and topsoil placement in permanent storm water basin areas will not be permitted until use of areas for temporary sedimentation basins is terminated.

1.8 TURF ESTABLISHMENT

A. All work shall be in accordance with the terms of Article 3.4, “General Guaranty” of the GENERAL CONDITIONS.

B. Water turf areas to maintain an adequate supply of moisture within the root zone. An adequate supply of moisture is the equivalent of one inch of absorbed water per week, either through natural rainfall or augmented by periodic waterings. Apply water at a moderate rate so as not to displace the mulch or flood the turf areas. Adequate moisture should be divided into two to three waterings per week, as directed by the Owner’s Representative. During the summer (June 2 through August 31) watering may be required on a daily basis, as directed by the Owner’s Representative. During the winter months confer with the Owner’s Representative regarding the frequency of watering.
C. General Acceptance: The Construction Administrator shall make an inspection of the seeded areas upon completion of seeding. Seeded areas shall be considered acceptable if the specified quantities of fertilizer and seed have been properly applied.

D. Guarantee: The Contractor is responsible for the proper application of the fertilizer and seed, and maintenance as noted within Sub-Section 3.6.

1.9 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 basic designation only.

B. Federal Specifications (Fed. Spec.):

- O-F-241D Fertilizers, Mixed, Commercial
- Q-P-166E Peat, Moss; Peat, Humus, and Peat, Reed-sedge

C. American Society for Testing and Materials (ASTM) Publications:

- C136 Sieve or Screen Analysis of Fine and Coarse Aggregates
- C516 Vermiculite Loose Fill Thermal Insulation
- C549 Perlite Loose Fill Insulation
- D977 Emulsified Asphalt
- D2028 Liquid Asphalt (rapid-curing type)


E. American Wood Preservative Association (AWPA):

- C-2-83 Lumber, Timber, Bridge Ties and Mine Ties-Pressure Treatment

PART 2 - PRODUCTS

2.1 MATERIALS

A. TOPSOIL

1. Topsoil shall be a well-graded soil of good uniform quality. It shall be a natural, friable soil representative of productive soils in the vicinity. Topsoil shall be free of admixture of subsoil, foreign matter, objects larger than one inch in any dimension, toxic substances, weeds and any material or substances that may be harmful to plant growth and shall have a pH value of not less than 5.0 nor more than 7.5. The Contractor shall submit an analysis of soils along with samples for approval by the Landscape Architect.

2. Material to be obtained from stockpiles, if any, established under Section SITE CLEARING, subparagraph, Stripping Topsoil, and shall meet the general requirements as stated above. Topsoil not meeting the pH range specified shall be amended by the addition of pH Adjusters.
B. SEED

1. Seed shall be state-certified seed of the latest season's crop and shall be delivered in original sealed packages bearing the producer's guaranteed analysis for percentages of mixtures, purity, germination, weed seed content, and inert material. Seed shall be labeled in conformance with U.S. Department of Agriculture rules and regulations under the Federal Seed Act and applicable state seed laws. Seed that has become wet, moldy, or otherwise damaged will not be acceptable. Onsite seed mixing shall be done only in the presence of the Landscape Architect. Seed mixtures shall be proportioned by weight as follows:

<table>
<thead>
<tr>
<th>NAME OF TURF GRASS</th>
<th>Percent by Weight</th>
<th>Percent Germination</th>
<th>Max. % Weed Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Lawn Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five-Star Turf Type Tall Fescue Blend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossfire II Tall Fescue</td>
<td>34%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td>Black Runner Tall Fescue</td>
<td>25%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td>Cayenne Tall Fescue</td>
<td>20%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td>Dynasty Tall Fescue</td>
<td>10%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td>Bravado Tall Fescue</td>
<td>10%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td>Plus Rye (annual)</td>
<td>5%</td>
<td>85%</td>
<td>2%</td>
</tr>
</tbody>
</table>

C. WATER

1. Water shall not contain elements toxic to plant life. It shall be obtained as specified in Section 01500, Construction Facilities and Temporary Controls.

D. HERBICIDES

1. All herbicides shall be properly labeled and registered with the U.S. Department of Agriculture. All herbicides shall be kept in the original labeled containers indicating the analysis and method of use.
   a. Post-Emergent Weed Control Acceptable Products
      1) Enide by Upjohn
      2) Dymid by Elanco
      3) Treflan or Surflan by Dow Agrosciences
      4) Eptan by Syngenta
      5) Equal as approved by Landscape Architect before use
E. TURF FERTILIZER

1. Fertilizer shall be commercial grade 50% slow release, free flowing, uniform in composition, and shall conform to applicable state and federal regulations. Liquid starter fertilizer for use in the hydroseed slurry will be commercial type with 50 percent of the nitrogen in slow release form.

F. MULCH

1. Mulch shall be free from deleterious materials and shall be stored as to prevent inclusion of foreign material.
2. Straw for lawn seed bed mulch shall be stalks from oats, wheat, rye, barley, or rice that are free from noxious weeds, mold or other objectionable material. Straw shall be in an air-dry condition and suitable for placing with blower equipment.
3. Wood cellulose fiber for use with hydraulic application of grass seed and fertilizer shall consist of specially prepared wood cellulose fiber, processed to contain no growth or germination-inhibiting factors, and dyed an appropriate color to facilitate visual metering of the application of materials. On an air-dry weight basis, the wood cellulose fiber shall contain a maximum of 12 percent moisture, plus or minus three percent at the time of manufacture. The pH range shall be from 3.5 to 5.0. The wood cellulose fiber shall be manufactured so that:
   a. After addition and agitation in slurry tanks with fertilizers, grass seeds, water, and other approved additives, the fibers in the material will become uniformly suspended to form homogeneous slurry.
   b. When hydraulically sprayed on the ground, the material will form a blotter like cover impregnated uniformly with grass seed.
   c. The cover will allow the absorption of moisture and allow rainfall or applied water to percolate to the underlying soil.

G. LIME

1. Lime shall be agricultural limestone containing not less than 85 percent calcium and magnesium carbonates and shall be ground to such fineness that at least 50 percent will pass through a 100-mesh sieve and at least 98 percent will pass through a 20-mesh sieve.

H. SOIL CONDITIONERS

1. Peat shall be a natural product of sphagnum moss peat derived from a fresh-water site conforming to Fed. Spec. Q-P-166, except as otherwise specified. Peat shall be shredded and granulated to pass through a 1/2-inch mesh screen and conditioned in storage piles for at least six months after excavation.
2. Sand shall be clean and free of toxic materials
3. Perlite shall conform to ASTM C549.
4. Vermiculite shall be horticultural grade and free of any toxic materials and conform to ASTM C516.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which seeding is to be performed and identify conditions detrimental to proper or timely completion.

1. Verify final grade has been established with adequate depth of topsoil in conformance with these specifications.
2. Verify topsoil meets requirements of this Section and soils testing lab report identifying required amendments is available.
3. Verify compaction requirements in Section 312000 have not been exceeded.
4. Do not proceed until unsatisfactory conditions have been corrected.
5. Owner and Architect shall approve all areas prior to applying seed.

3.2 SOIL MODIFICATIONS

B. Subsoil Preparation:

1. Till compacted soils to a depth of 8 inches minimum.
2. Remove all buried rocks and debris that is larger than 1” in any direction. Utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (eg. sticks, roots, trash and other extraneous matter).

B. Topsoil Preparation:

1. Weed Control: Apply “Round-up”, “Ortho Weed-B-Gon” or “Spectracide Triple Strike” to heavily weeded areas at least one week prior to working the soil. Owner’s Representative shall be notified 48 hours in advance to be present to view and approve product and application on site.
2. Remove all buried rocks and debris that is larger than 1” in any direction. Contractor shall utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (eg. sticks, roots, trash and other extraneous matter).
3. Amendments: Test topsoil for fertility and apply amendments as required, with the following general guidelines:
   a. Add 1-2 pounds each of Nitrogen, Phosphorous, and Potassium per 1000 square feet.
   b. Till the fertilizer into the top 3-4 inches of topsoil immediately after application.
   c. Owner’s Representative shall be notified to be 48 hours in advance to be present to view and approve products and application on site.

3.3 TURF GRASS PREPARATION

A. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 8 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter, and legally dispose of them off Owner’s property.
1. Spread planting soil mix to a minimum depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

2. Blend a portion of topsoil with the top 2-3 inches of subsoil.

B. Unchanged Subgrades:

1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.

2. Remove all buried rocks and debris that is larger than 1” in any direction. Contractor shall utilize a preparatory Bobcat attachment to loosen soil and remove rocks and debris (e.g. sticks, roots, trash and other extraneous matter).

3. Loosen surface soil to a depth of at least 6 inches. Till soil to a homogeneous mixture of fine texture.

4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner’s property.

C. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus ½ inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.

D. Final Soil Preparation: Prepare soil not less than 24 hours prior to planting.

1. Rake soil surfaces to completely scarify subsoil to a depth of 2 inches and remove solid crust no more than one day prior to laying sod.

2. Clods should be broken down to 1-5 mm, and then rolled until firm.

3. Level any uneven areas.

E. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Restore areas if eroded or otherwise disturbed after finish grading and before planting.

3.4 APPLICATION OF FERTILIZER FOR TURF AREAS

A. Apply 400 lbs of 10-20-10 and 400 lbs of 0-20-0 per acre. In addition, adjust soil acidity and add soil conditioners as required herein for suitable topsoil under this Section.

B. Incorporate fertilizers and lime into the soil to a depth of at least four inches and incorporate these as part of the tillage operation specified. Immediately before any turf work, the soil shall be restored to an even condition.

3.5 HYDROSEEDING & HYDROMULCHING – TURF GRASS

A. When hydroseeding and hydromulching, mix the seed and slow release starter fertilizer, or the seed, fertilizer, lime (in addition to lime and fertilizer applied directly to the soil mechanically) when required and approved wood cellulose mulch material in the required amount of water to produce a homogeneous slurry and then uniformly apply slurry under pressure at the following rate. Slurry shall consist of 5 pounds of seed and fertilizer in accordance with Manufacturers’ instructions in 16 gallons of water per 1,000 square feet. When using wood cellulose mulch, incorporate it as an integral part of the slurry mix after the seed and fertilizer have been thoroughly mixed. Apply the slurry mix uniformly at a rate of application as required to obtain 5 pounds of seed per 1000 square feet (dry weight).
3.6 WATERING & MAINTENANCE

A. General: The project areas shall be kept clean at all times and care shall be taken that use of the premises shall not be unduly hampered by Work herein specified. The intent of this Section is to ensure a healthy, well-established turf and prevent soil erosion in compliance with the SWPPP.

B. The watering and maintenance shall comply with subsections 1.8 and 3.9.

C. Seeded lawn areas will not be accepted as complete until they conform with subsection 3.9.

D. Apply fertilizer as needed to obtain satisfactory lawn, as noted in subsection 3.9.

3.7 PROTECTION OF TURF AREAS

A. Immediately after installation of the turf areas, protect against traffic or other use by erecting barricades, as required, and placing approved signs at appropriate intervals until final acceptance.

3.8 FINAL CLEAN-UP

A. Remove all debris, rubbish and excess material from the site and dispose of it according to all applicable regulations.

3.9 SATISFACTORY LAWNS

A. Field Inspection:

1. Seeded areas will be accepted at Substantial Completion if:
   a. Seeded areas are properly established such that within any 10’ x 10’ area of turf there is less than 5% weed coverage; lawn is free of bare and dead spots; and no surface soil is visible when grass has been cut to height of 2-1/2 inches.

2. Seeded areas have been mowed a minimum of twice.
   a. At time of first cutting, mower blades shall be set to produce a 2-1/2-inch mowed height.

B. Maintain lawn areas from completion of installation to 60 days after substantial completion. Areas seeded after November 1 will be reviewed for acceptance the following spring approximately one month after start of growing season.

C. Re-seed areas that do not comply with requirements until areas are satisfactory. Replaced lawn areas shall be guaranteed and maintained by the Contractor for an additional 30 days from date of replacement.

D. Mowing:

1. Beginning at Acceptance of the Landscape Installation (sitework substantial completion) and continuing for a 60-day period, mow entire project limits once each seven (7) days with no less than five (5) days between mowing.
2. Trash and litter shall be removed from area to be mown prior to mowing and taken off-site, if no public trash containers are available.

3. All mowing equipment shall be equipped with sharp blades that do not tear the grass but cleanly cut the grass.

4. All grass shall be mowed to two-thirds of its pre-cut height and to a maximum height of three inches.

5. All sidewalks, curbs, and steps shall be mechanically trimmed. Chemical edging by Contractor shall not be permitted.

6. All structures, trees, poles, signs, fences, walls and shrub beds are to be trimmed closely. Trimming shall be accomplished concurrently with mowing.

7. The mowed area shall be free of clumped grass and not show tire tracks or ruts from mowing equipment.

8. Mowing shall not discharge grass clippings onto paved areas or other improved areas. Any materials from mowing operations blown or discharged on to such areas shall be removed immediately.

9. Grass clippings may be finely cut by use of a mulching-type mower. Removal of clippings from turf areas will not be required, if clippings are mulched in such manner.

10. Mowing or trimming operations shall not damage plants or other improvements.

END OF SECTION 329220
PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Requirements of the Contract, including Special Conditions and Division 1 Specifications that apply to this Section.

1.2 DESCRIPTION

A. This work consists of furnishing and installing all planting materials required for landscaping hereinafter specified in locations as shown. Substantial completion date for site work may vary from that of the building substantial completion date.

1.3 EQUIPMENT

A. Maintain all equipment, tools and machinery while on the project in sufficient quantities and capacity for proper execution of the work.

1.4 RELATED WORK

A. Stripping Topsoil and Stock Piling

B. Topsoil Testing

C. Turf Seeding

D. Turf Sodding

1.5 SUBMITTALS

A. Product Data and/or Certificates of Conformance or Compliance: Before delivery, notarized certificates attesting that the following materials meet the requirements specified shall be submitted to the Landscape Architect for approval:

1. Plant Materials (Department of Agriculture certification by State Nursery Inspector declaring material to be free from insects and disease).

2. Fertilizers.

3. Lime.

4. Peat.

5. Herbicide.


7. Soils Analysis
1.6 DELIVERY AND STORAGE

A. Delivery:

1. Notify the Landscape Architect of the delivery schedule in advance so the plant material may be inspected upon arrival at the job site. Remove unacceptable plant material from the job site immediately.
2. Protect plants during delivery to prevent damage to root balls or desiccation of leaves. Protect trees during transport by tying in the branches and covering all exposed branches.
3. The use of equipment such as “tree spades” is permitted provided the plant balls are sized in accordance with ANSI Z60.1 and tops are protected from damage.
4. Deliver fertilizer and lime to the site in the original, unopened containers bearing the manufacturer’s guaranteed chemical analysis, name, trade name or trademark, and in conformance to state and federal law. In lieu of containers, fertilizer and lime may be furnished in bulk and a certificate indicating the above information shall accompany each delivery.

B. Storage:

1. Keep seed, lime, and fertilizer in dry storage away from contaminants.
2. Store plants not installed on the day of arrival at the site as follows:
   a. Outside storage to be shaded and protected from the wind.
   b. Heel in bare root plants.
   c. Protect plants stored on the project from drying out at all times by covering the balls or roots with moist sawdust, wood chips, shredded bark, peat moss, or other similar mulching material.
   d. Keep plants, including those in containers, in a moist condition until planted, by watering with fine mist spray.

1.7 PLANT ESTABLISHMENT AND GUARANTEE PERIOD

All work shall be in accordance with the terms of the Paragraph, “Guaranty” of Section GENERAL CONDITIONS, including the following supplements:

A. Establishment period for plants shall begin immediately after installation and continue 60 days after the final inspection at the site work’s substantial completion. Following completion of any corrective measures required for achieving substantial completion, the maintenance will be taken over by the Owner. During the Plant Establishment Period the Contractor shall:

1. Water all plants to maintain an adequate supply of moisture within the root zone. An adequate supply of moisture is the equivalent of one inch of absorbed water per week either through natural rainfall or augmented by periodic waterings. Apply water at a moderate rate so as not to displace the mulch or flood the plants. Additional water may be required, as needed, for plant establishment during the summer (June 2 through August 31).
2. Prune plants and replace mulch as required.
3. Replace and restore stakes, guy wires and eroded plant saucers as required.
4. In plant beds, remove grass and weeds, including the root growth, before they reach a height of three inches.

5. Spray by a licensed State Certified Applicator using approved insecticides and fungicides to control pests and ensure plant survival in a healthy growing condition, as directed by the Landscape Architect.

6. Remove any plants that die during this period and replace them with plants of the same size and species.

7. The Contractor is not responsible for theft or damage to plants by non-contractor vehicles or vandalism once plants are installed and approved at site work substantial completion.

B. The One Year Plant Guarantee Period will begin on the date that the Owner performs a final inspection for substantial completion. All planting work shall have been completed, located and installed according to the plans and specifications, and all plants shall be in a living and healthy condition at the time of final inspection.

C. Termination of the Plant Guarantee Period: The Owner will inspect all plants at the end of the One Year Guarantee Period. The Guarantee Period will end on the date of this inspection provided the Contractor has complied with the work required. The Contractor shall also provide and install replacement plant material for dead, missing, or defective plant material. Replacement material shall be guaranteed an additional year from the date of replacement.

1.8 APPLICABLE PUBLICATIONS

A. The publications listed below, form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. Federal Specifications (Fed. Spec.):

   - O-F-241D  Fertilizers, Mixed, Commercial
   - Q-P-166E  Peat, Moss; Peat, Humus, and Peat, Reed-sedge

C. American National Standards Institute (ANSI) Publications:

   - ANSI Z60.1  Nursery Stock
   - ANSI Z133.1  Tree Care Operations-Pruning, Trimming, Repairing, Removal etc.- Safety Requirements


E. American Society For Testing And Materials (ASTM) Publications:

   - C136  Sieve or Screen Analysis of Fine and Coarse Aggregates
   - C516  Vermiculite Loose Fill Thermal Insulation
   - C549  Perlite Loose Fill Insulation
PART 2 - PRODUCTS

2.1 GENERAL

A. All plant material will conform to the varieties specified or shown in the plant list and be true to botanical name as listed in Hortus Third.

2.2 PLANTS

A. Plants shall be in accordance with ANSI Z60.1, except as otherwise stated in the specifications or shown on the plans. Where the drawings or specifications are in conflict with ANSI Z60.1, the drawings and specification shall prevail.

B. Provide well-branched and formed planting stock, sound, vigorous, and free from disease, sunscald, windburn, abrasion, harmful insects or insect eggs with healthy, normal, and unbroken root systems. Trees, deciduous and evergreen, will be single trunked with a single leader, unless otherwise indicated, and display no weak crotches. Provide symmetrically developed deciduous trees and shrubs of uniform habit of growth, with straight boles or stems and free from objectionable disfigurements, and evergreen trees and shrubs with well developed symmetrical tops with typical spread of branches for each particular species or variety. Provide ground cover and vine plants with the number and length of runners for the size specified, and the proper age for the grade of plants specified. Provide vines and ground cover plants well established in removable containers, integral containers, or formed homogeneous soil sections. Plants shall have been grown under climatic conditions similar to those in the locality of the project. Spray all plants budding into leaf or having soft growth with an anti-desiccant at the nursery before digging.

C. The minimum acceptable sizes of all plants, measured before pruning with branches in normal position, shall conform to the measurements designated. Plants larger in size than specified may be used with the approval of the Landscape Architect, with no change in the contract price. When larger plants are used, increase the ball of earth or spread of roots in accordance with ANSI Z60.1.

D. Provide nursery grown plant material conforming to the requirements and recommendations of ANSI Z60.1. Dig and prepare plants for shipment in a manner that will not cause damage to branches, shape, and future development after planting.

E. Balled and burlapped (B&B) plant ball sizes and ratios will conform to ANSI Z60.1, consisting of firm, natural balls of soil wrapped firmly with burlap or strong cloth and tied.
F. Bare-root (BR) plants shall be dug with the root system substantially intact, but with the
earth carefully removed. Cover roots with a thick coating of mud by “puddling” after the
plants are dug.

G. Container grown plants shall have sufficient root growth to hold the earth intact when
removed from containers, but shall not be root bound.

H. Make substitutions only when a plant (or its alternates as specified) is not obtainable
and the Landscape Architect authorizes a change order providing for use of the nearest
equivalent obtainable size or variety of plant having the same essential characteristics
with an equitable adjustment of the contract price.

I. When existing plants are to be relocated, ball sizes shall conform to requirements for
collected plants in ANSI Z60.1, and plants shall be dug, handled and replanted in
accordance with applicable sections of these specifications.

2.3 LABELS

A. Each plant, or group and bundles or containers of the same species, variety, and size of
plant, shall be legibly tagged with a durable, waterproof and weather-resistant label
indicating the correct plant name and size specified in the plant list. Labels shall be
securely attached and not be removed.

2.4 TOPSOIL

A. Topsoil shall be a well-graded soil of good uniform quality. It shall be a natural, friable soil
representative of productive soils in the vicinity. Topsoil shall be free of admixture of
subsoil, foreign matter, objects larger than one inch in any dimension, toxic substances,
weeds and any material or substances that may be harmful to plant growth and shall have
a pH value of not less than 5.0 nor more than 7.5. The Contractor shall submit an analysis
of soils along with samples for approval by the Landscape Architect. Soil testing shall be
performed by state university soils science department, soils testing laboratory, or other
recognized soil physics testing laboratory with recommendation for type and application
rate of amendments needed to adjust topsoil to required nutrient levels for each proposed
landscape operation, i.e., seeding, sodding, ground covers, etc.

B. Material to be obtained from stockpiles, if any, established under Section SITE CLEARING,
subparagraph, Stripping Topsoil, and shall meet the general requirements as stated above.
Topsoil not meeting the pH range specified shall be amended by the addition of pH
Adjusters.

2.5 LIME

A. Lime shall be agricultural limestone containing not less than 85 percent calcium and
magnesium carbonates, and shall be ground to such fineness that at least 50 percent will
pass through a 100-mesh sieve and at least 98 percent will pass through a 20-mesh sieve.

2.6 SOIL CONDITIONERS

A. Peat shall be a natural product of sphagnum moss peat derived from a fresh-water site
conforming to Fed. Spec. Q-P-166, except as otherwise specified. Peat shall be shredded
and granulated to pass through a 1/2-inch mesh screen and conditioned in storage piles for at least six months after excavation.

B. Sand shall be clean and free of toxic materials.

C. Perlite shall conform to ASTM C549.

D. Vermiculite shall be horticultural grade and free of any toxic materials and conform to ASTM C516.

2.7 PLANTING SOIL MIXTURE

A. The planting soil mixture shall be composed of 2/3 topsoil and 1/3 organic peat moss, and washed sand mix, free from silt and clay.

2.8 PLANT FERTILIZER

A. Fertilizer shall be commercial grade 50% slow release and uniform in composition and shall conform to applicable state and federal regulations.

B. For new plant material provide packet, table, or pellet forms of slow release fertilizers conforming to Fed. Spec. O-F-241, bearing the manufacturer's guaranteed statement of analysis. Slow release fertilizers shall contain a minimum percentage by weight of 10% nitrogen (of which 50 percent will be organic), 10% available phosphoric acid, and 10% potash.

C. Provide granular fertilizer for existing trees conforming to Fed. Spec. O-F-241, Type I, Class 2, and shall bear the manufacturer's guaranteed statement of analysis. Granular fertilizer shall contain a minimum percentage by weight of 10% nitrogen (of which 50 percent shall be organic), 10% available phosphoric acid, and 10% potash.

2.9 MEMBRANES

A. Water permeable filtration fabric of fiberglass or polypropylene.

2.10 MULCH

A. Mulch shall be free from deleterious materials and shall be stored as to prevent inclusion of foreign material.

B. Inert mulch materials shall be washed river gravel and shall range in size from 1-inch to 2-1/2 inches in accordance with ASTM C 136.

C. Organic mulch materials for planting beds shall be shredded hardwood mulch.

D. Straw for lawn seed bed mulch shall be stalks from oats, wheat, rye, barley, or rice that are free from noxious weeds, mold or other objectionable material. Straw shall be in an air-dry condition and suitable for placing with blower equipment.

E. Wood cellulose fiber for use with hydraulic application of grass seed and fertilizer shall consist of specially prepared wood cellulose fiber, processed to contain no growth or
germination-inhibiting factors, and dyed an appropriate color to facilitate visual metering of the application of materials. On an air-dry weight basis, the wood cellulose fiber shall contain a maximum of 12 percent moisture, plus or minus three percent at the time of manufacture. The pH range shall be from 3.5 to 5.0. The wood cellulose fiber shall be manufactured so that:

1. After addition and agitation in slurry tanks with fertilizers, grass seeds, water, and other approved additives, the fibers in the material will become uniformly suspended to form a homogeneous slurry.

2. When hydraulically sprayed on the ground, the material will form a blotter like cover impregnated uniformly with grass seed.

3. The cover will allow the absorption of moisture and allow rainfall or applied water to percolate to the underlying soil.

2.11 GUYING AND STAKING MATERIALS

A. Provide stakes for tree support of steel “T” posts. Stakes shall be a minimum of 2 inches by 2 inches, or 2-1/2 inches in diameter, by 8 feet long and pointed at one end.

B. Guying wire shall be pliable, zinc-coated iron of No. 12 gauge, twisted in a double strand allowing for tightening and loosening the guywire during the guarantee period.

C. Hose chafing guards shall be new 2-ply reinforced rubber garden hose, having an inside diameter of not less than 2-inch (minimum length 18 inches), of all the same color on the project.

D. Flags to be fastened to guys shall be surveyor’s plastic tape, white in color and six inches in length.

2.12 WATER

A. Water shall not contain elements toxic to plant life. It shall be obtained as specified in Section, GENERAL REQUIREMENTS, paragraph, Temporary Services at no cost to the Contractor.

2.13 ANTIDESICCANT

A. Antidesiccant shall be an emulsion that will provide a film over plant surfaces permeable enough to permit transpiration.

2.14 HERBICIDES

A. All herbicides shall be properly labeled and registered with the U.S. Department of Agriculture. All herbicides shall be kept in the original labeled containers indicating the analysis and method of use. Pre-emergent herbicide shall be Treflan (trifluralin), or approved equal, in the 5 percent granular form for Spring planting. Fall plantings should use Dymid in the 5 percent granular form or approved equal.
PART 3 - EXECUTION

3.1 PLANTING INSTALLATION SEASONS AND CONDITIONS

A. Perform operations within the following dates: From March 15 to June 1 for spring and from September 1 to November 1 for fall.

B. No work shall be done when the ground is frozen, snow covered, too wet or in an otherwise unsuitable condition for planting. Special conditions may exist that warrants a variance in the specified planting dates or conditions. A written request shall be submitted to the Landscape Architect stating the special conditions and proposal variance.

3.2 LAYOUT

A. Stake plant material locations and bed outlines on project site for approval by the Landscape Architect before any plant pits or beds are dug. The Landscape Architect may approve adjustments to plant material locations to meet field conditions.

3.3 EXCAVATION FOR PLANTING

A. Prior to excavating for plant pits and bed, verify the location of any underground utilities. Damage to utility lines will be repaired at the Contractor's expense. Where lawns have been established prior to planting operation, cover the surrounding turf before excavations are made in a manner that will protect turf areas. Existing trees, shrubbery, and beds that are to be preserved shall be barricaded in a manner that will effectively protect them during the project construction.

B. Remove rocks and other underground obstructions to a depth necessary to permit proper planting according to plans and specifications. Where underground utilities, construction, or solid rock ledges are encountered, other locations may be selected by the Landscape Architect.

C. Plant pits may be dug by any approved method provided that the pits have vertical sides and flat bottoms. When pits are dug with an auger and the sides of the pits become glazed, the glazed surface shall be scarified. Size the plant pits as shown, otherwise, the minimum allowable depth of plant pits shall be the same depth as the ball, and pit diameter shall be 1-1/2 times the diameter of the ball.

D. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure the removal of the entire root system, with additional bed preparation as specified in the next paragraph.

E. Where existing soil is to be used in place, till new planting beds to a depth of four inches. Spread peat uniformly over the bed to depth of two inches and thoroughly incorporate it into the existing soil to a depth of four inches using a roto-tiller or similar type of equipment to obtain a uniform and well pulverized soil mix. During tillage operations remove all sticks, stones, roots, and other objectionable materials. Plant beds shall be brought to a smooth and even surface conforming to established grades.

F. In areas of new grading where existing soil is being replaced for the construction of new planting beds, remove 6 inches of existing soil and replace with topsoil. Planting beds shall
be brought to a smooth and even surface conforming to established grades. Till two inches of peat into the topsoil as specified.

G. Form watering saucers around plants, with topsoil.

H. Treat plant saucers, shrub, and ground cover bed areas, prior to mulching, with an approved pre-emergent herbicide. Thoroughly incorporate the pre-emergent herbicide in a uniform manner in accordance with the Manufacturer’s instructions and all applicable governmental regulations. Within 3 hours of pre-emergent herbicide application, the soil must be thoroughly watered by uniform spraying. (This watering may occur prior to, or after shrub planting and mulch placement.) Plant ground cover in areas to receive erosion control material through the material after material is in place.

3.4 SETTING PLANTS

A. Handle balled and burlapped and container-grown plants only by the ball or container. Set plants plumb and hold in position until sufficient soil has been firmly placed around the roots or ball. Set plants in relation to surrounding grade so that the root flare is even with the surrounding grade. Plant ground cover plants after the mulch is in place. Avoid contaminating the mulch with the planting soil. Add slow release packet, tablet or pellet fertilizer as each plant is installed as per manufacturer’s recommendation for method of installation and quantity.

B. Backfill balled and burlapped stock with Planting Soil Mixture as specified to approximately half the depth of the ball and then tamp and water. Carefully remove excess burlap and tying materials and fold back. Where plastic wrap or treated burlap is used in lieu of burlap, completely remove these materials before backfilling. Tamp and water remainder of backfill Planting Soil Mixture; then form earth saucers or water basins around isolated plants with topsoil.

C. Plant bare-root stock arranging the roots in a natural position. Remove damaged roots with a clean cut. Planting Soil Mixture shall be carefully worked in among the roots. Tamp and water the remainder of Planting Soil Mixture; then form earth saucers or water basins around isolated plants with topsoil.

3.5 REMOVING CONTAINER GROWN STOCK

A. Remove from containers in such a way to prevent damage to plant or root system. Complete planting as specified under balled and burlapped plants.

3.6 FERTILIZATION OF EXISTING TREES

A. Apply fertilizer to existing trees shown on the drawings at the rate of 2 pounds per inch caliper. Apply in 12-inch to 18-inch deep holes 1-1/2 to 2 inches in diameter, made by an earth auger, distributed evenly at not more than two feet on center throughout the outer half of the branch spread zone of each tree. Fertilize to within four inches of the surrounding grade. Use topsoil to bring the surface up to the surrounding grade. When using fertilizer in packet, tablet, or wedge form, apply in accordance with manufacturer’s recommendations.
3.7 MULCHING PLANTS

A. Mulch within 48 hours after planting and after applying the pre-emergent herbicide, except ground cover areas which shall have organic material placed before planting.

B. Placing Inert Material: Place water permeable filtration fabric with edges lapped 6 inches to 12 inches to receive inert mulch material. Spread inert mulch to a uniform thickness over the membrane as shown.

C. Placing Organic Material: A mulch of shredded hardwood shall be spread to a uniform minimum thickness of two inches. Keep mulch two inches away from all sides of every tree trunk.

D. Keep mulch out of the crowns of shrubs and off buildings, sidewalks, light standards, and other structures.

3.8 STAKING AND GUYING

A. Stake and guy plants as shown on the drawings and as specified only if directed by the Landscape Architect.

B. Drive stakes vertically into the ground to a depth of 2-1/2 to 3 feet in such a manner as not to injure the ball or roots, unless otherwise shown on the drawings.

C. Place deadmen not less than 18 inches below the surface of the ground, unless otherwise shown on the drawings.

D. Install iron anchors according to manufacturer's recommendations.

E. Fasten flags securely on each guy wire approximately 2/3 of the distance up from ground level.

3.9 PRUNING

A. Prune new plant material in the following manner: Only remove dead, broken or crossing branches. Make cuts with sharp instruments as close as possible to the branch collar without cutting into branch collar. Do not make flush cuts or stub cuts. No "Headback" cuts at right angles to line of growth is permitted. Do not pole trees or remove the leader. Remove trimmings from the site.

3.10 RESTORATION AND CLEAN-UP

A. Remove excess and waste material daily. When planting work in an area has been completed, clear the area of all debris, spoil piles, and containers. Where existing or new turf areas have been damaged or scarred during planting and construction operations, restore disturbed area to their original condition. At least one paved pedestrian access route and one paved vehicular access route to each building shall be kept clean at all times. Clear all other paved areas when work in adjacent areas is completed.
3.11 MAINTENANCE

A. Before beginning maintenance period, plants shall be in at least as sound, healthy, vigorous, and in approved condition as when delivered to site, unless accepted by Architect in writing at final landscape inspection.

B. Maintenance operations shall begin immediately after each plant is planted and continue as required. Keep plants in a healthy, growing condition by watering, pruning, spraying, weeding, and any other necessary operation of maintenance. Keep plant saucers and beds free of weeds, grass, and other undesired vegetation. Inspect plants once per week during the installation period and perform needed maintenance promptly. **Water as noted in subsection 1.7.**

C. Maintain landscaping from completion of landscape installation to 30 days after substantial completion. Areas installed after November 1 will be reviewed for acceptance the following spring approximately one month after start of growing season.

D. Replace landscaping that is dead or appears unhealthy or non-vigorous as directed by Architect before end of maintenance period. Make replacements within 10 days of notification.

3.12 FINAL CLEAN-UP

A. Remove all debris, rubbish and excess material from the Site.

END OF SECTION 329300
SECTION 331123 – NATURAL GAS DISTRIBUTION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Natural gas distribution installation shall comply with “City Utilities, Contract Documents Exhibit B, Construction Specifications for Developer Installed Gas, Water and Electric Utilities.” Installation (labor and materials) will be completed by City Utilities.

1.2 COST:

A. The cost allowance (refer to Section 012100) is for installation of the natural gas service and meter (refer to City Utilities drawing CU-1 within the plan set as well as the Cost Memorandum within specification Section 012100). This includes the amount to be paid to City Utilities for the materials and labor for the meter set and service.

END OF SECTION 331123
PART 1 – DESCRIPTION

1.1 DESCRIPTION

A. This item shall consist of the construction of pipe culverts and storm drains in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans. The pipe materials shall conform to the requirements of the current edition of the Missouri Standard Specification for Highway Construction (MSSH), Section 725 - Metal Pipe and Pipe-Arch Culverts, Section 726 - Rigid Pipe Culverts, Storm Drains and Sewers, and Section 732 - Flared End Sections.

B. All construction methods, testing, and acceptance criteria shall be in accordance with the standards included within this Section 02630.

PART 2 – MATERIALS

2.1 PIPE MATERIALS

A. Pipe materials shall conform to the requirements of the MSSHC, as follows:

- Corrugated Metallic-Coated Steel Pipe
  - Section 725
- Reinforced Concrete Pipe – ASTM C 76
  - Class IV and V
  - Section 726
- Flared End Sections
  - Section 732
- Ductile Iron Pipe
  - Pipe and fittings shall conform to American National Standards Institute (ANSI) A-21.5, thickness Class 51 min. with mechanical joints or slip on joints.
- SDR 21 Class 200 PVC Pipe
  - Pipe shall conform to ASTM designation D2241. Fittings shall conform to ASTM designation D2241 or as otherwise shown on the drawings.

B. Prior to the use of materials, the contractor shall furnish manufacturer’s certified test reports to the Engineer for those materials proposed for use during construction. The certified test reports shall include a statement that the materials meet the specification requirements.

2.2 CONCRETE

A. Concrete for pipe cradles shall have a minimum compressive strength of 2000 psi at 28 days and conform to the requirements of ASTM C 94.
PART 3 – CONSTRUCTION METHODS

3.1 EXCAVATION.

A. The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe, but it shall not be less than the external diameter of the pipe plus 6 inches on each side. The trench walls shall be approximately vertical.

B. Where rock, hardpan, or other unyielding material is encountered, the Contractor shall remove it from below the foundation grade for a depth of at least 12 inches or one-half inch for each foot of fill over the top of the pipe (whichever is greater) but for no more than three-quarters of the nominal diameter of the pipe. The width of the excavation shall be at least 1 foot greater than the horizontal outside diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 6 inches in uncompacted depth to form a uniform but yielding foundation, except below all existing or future pavements the backfill shall be granular bedding material.

C. Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, the unstable soil shall be removed and replaced with approved granular material for the full trench width. The Engineer shall determine the depth of removal necessary. The granular material shall be compacted to provide adequate support for the pipe.

D. The excavation for pipes that are placed in embankment fill shall not be made until the embankment has been completed to a height above the top of the pipe as shown on the plans.

3.2 BEDDING

A. Bedding for reinforced concrete pipe will be classified as Class A, Class B, or Class C. When no bedding class is specified or detailed on the plans, the requirements for Class C bedding shall apply.

B. Reinforced Concrete and Ductile Iron Pipe.

1. Class A bedding shall be used if, in the judgment of the engineer, soil conditions are such that a firm bed cannot be otherwise secured. The pipe shall be laid in the center of a concrete cradle having a minimum width of 6 inches greater than the outside diameter of the pipe. The minimum thickness of the cradle under the bottom of the pipe shall be 1/4 of the internal diameter of the pipe, and the cradle shall extend up the sides of the pipe for a height equal to 1/4 its outside diameter. The concrete shall meet the requirements of Section 03400.

2. Class B bedding shall consist of a bed of granular material having a thickness of at least 6 inches below the bottom of the pipe and extending up around the pipe for a depth of not less than 30 percent of the pipe’s vertical outside diameter. The layer of bedding material shall be shaped to fit the pipe for at least 10 percent of the pipe’s vertical diameter and shall have recesses shaped to receive the bell of bell and spigot pipe. The bedding
material shall be sand or selected sandy soil, all of which passes a 3/8 inch (9mm) sieve and not more than 10 percent of which passes a No. 200 (0.075 mm) sieve.

3. Class C bedding shall consist of a soil foundation shaped to fit the lower part of the pipe exterior for at least 10 percent of its overall height and shall afford a uniformly firm bed throughout its entire length. In lieu of Class C bedding, Class B bedding may be used at no additional cost to the Owner.

C. Corrugated Metal and PVC Pipe.

1. For corrugated metal and PVC pipe, the bed shall be roughly shaped to fit the pipe, and a 4” bedding blanket of sand or fine granular material shall be provided below the pipe and a minimum of 12” above the top of pipe.

3.3 LAYING PIPE

A. The pipe laying shall begin at the lowest point of the trench and proceed upgrade. The lower segment of the pipe shall be in contact with the bedding throughout its full length. Bell or groove ends of rigid pipes and outside circumferential laps of flexible pipes shall be placed facing upgrade.

B. Pipe shall be installed to the lines and grades indicated.

C. Paved or partially lined pipe shall be placed so that the longitudinal center line of the paved segment coincides with the flow line.

D. Elliptical and elliptically reinforced pipes shall be placed with the manufacturer’s top of pipe mark within five degrees of a vertical plane through the longitudinal axis of the pipe.

3.4 JOINING PIPE

A. All joints shall be sealed with an approved plastic compound, cement mortar or tubular joint seal. Rubber gasketed joints may be used at no additional cost to the sponsor. Where permissible lift holes have been used, the holes shall be carefully filled with expansive mortar to provide a watertight section. The mortar shall be finished flush on the inside of the pipe and shall be properly cured on the outside. Lifting devices shall have sufficient bearing on the inside of the pipe to avoid damage resulting from a concentration of stresses around the lift holes.

B. If rubber gasket type pipe is specified or used, the joints shall be installed in accordance with the manufacturer’s recommendations to ensure that joint devices are properly installed and that rubber gaskets are not displaced.

C. In sealing rigid pipe with mortar, the mortar contact areas of all pipe ends shall be damp when mortar is applied. After applying mortar to the entire interior surface of the bell or groove, the spigot or tongue end shall be forced into position. Any remaining void in the bell or groove shall be filled with a hub of mortar built up adjacent to the bell, or a bead of mortar built up around a groove-type joint. The interior joints of either type of pipe shall be finished flush with the surface of the pipe. Outside surface of mortar joints shall be cured with membrane curing compound.
D. In sealing rigid pipe with plastic joint compound, trowel grade compound shall be applied to the mating surfaces of both the tongue and groove, or to the entire interior surface of the bell and the upper portion of the spigot. Rope or tape type plastic compound shall be applied in accordance with the manufacturer’s recommendations. The joints shall be forced together with excess compound extruding both inside and outside the joint. Excess compound shall be removed from the interior surface where accessible. Tubular joint seals shall be installed in a manner as recommended by the manufacturer. The joint between the bell and spigot shall be uniform for the full circumference and care shall be taken to prevent the bell from supporting the spigot.

E. In joining corrugated metal pipe, the ends shall be butted as closely as the corrugations will permit and shall be joined with a firmly bolted coupling band of the same material as the pipe.

3.5 BACKFILLING

A. Pipes shall be inspected before any backfill is placed; any pipes found to be out of alignment, unduly settled, or damaged shall be removed and re-layed or replaced at the Contractor's expense.

B. Material for backfill shall be fine, readily compatible soil, or granular material selected from the excavation or a source of the Contractor’s choosing. It shall not contain frozen lumps, stones that would be retained on a 2-inch sieve, chunks of highly plastic clay, or other objectionable material. No less than 95 percent of a granular backfill material shall pass through a 1/2-inch sieve, and no less than 95 percent of it shall be retained on a No. 4 sieve.

C. When the top of the pipe is even with or below the top of the trench, the backfill shall be compacted in layers not exceeding 6 inches on both sides of the pipe and shall be brought up one foot above the top of the pipe or to natural ground level, whichever is greater. Care shall be exercised to thoroughly compact the backfill material under the haunches of the pipe. Material shall be brought up evenly on both sides of the pipe.

D. When the top of the pipe is above the top of the trench, the backfill shall be compacted in layers not exceeding 6 inches and shall be brought up evenly on both sides of the pipe to 1 foot above the top of the pipe. The width of backfill on each side of the pipe for the portion above the top of the trench shall be equal to twice the pipe’s diameter or 12 feet, whichever is less.

E. All backfill shall be compacted to the density required under Section 02315.

F. Testing frequency beneath pavements and buildings – 1 test per side of trench per 100 feet (per lift). Testing at the expense of Contractor.

END OF SECTION 334000
SECTION 344116 TRAFFIC CONTROL

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment and means to provide the Traffic Control for the project site as required to permit the installation of the facilities and dispose of materials. CONTRACTOR shall pay for all permits required under this Specification.

1.2 STANDARD SPECIFICATIONS

A. All work, installation, procedures, materials, etc. shall conform to the current edition of the Manual on Uniform Traffic Control Devices for streets and highways and the current edition of the Standard Specifications for Highway Construction by the Missouri Department of Transportation, except as modified by this Specification.

1.3 CONTRACTORS ORGANIZATION

A. The CONTRACTOR shall have a competent supervisor on the site during the process of the work who shall act for the CONTRACTOR in all matters concerning the work. He shall have the authority to receive directions and to act upon directions from the Contracting Officer.

1.4 RELATED WORK

A. Refer to Specification Section 312000 – Earthwork for work pertaining to excavation and backfilling.

1.5 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division – 1 Specification Sections apply to work of this section.

1.6 PAYMENT

A. All work required under this Section shall be included in the Lump Sum Contract Price.

PART 2 – PRODUCTS

2.1 MATERIALS

A. The CONTRACTOR shall provide all materials and equipment required to provide the Traffic Control for the project site in accordance with this Specification.

PART 3 – EXECUTION

3.1 EXCATIONS FOR PIPE LAYING

A. Excavations for pipe laying shall be conducted to cause the least interruption to traffic. The CONTRACTOR shall provide suitable bridges at street and driveway crossings where traffic must cross open trenches. Hydrants under pressure valve pit covers, valve boxes, curb stop
boxes, fire or police call boxes or other utility controls shall be unobstructed and accessible during the construction period.

B. CONTRACTOR shall be solely responsible for providing and installing any and all traffic barricades, markers, signs, flagman, traffic police, and/or other facilities as may be required by the city, township, county or state to protect the general public. Signs and protective devices shall conform to the “Manual on Uniform Traffic Control Devices” for streets and highways. Vehicular traffic shall be maintained at all times. Competent uniformed traffic directors shall be employed at every location where the CONTRACTOR’s equipment is working immediately adjacent to, or is entering, leaving or crossing active traffic lines. The traffic directors shall be employed continuously for the full time such conditions exist.

C. Special attention shall be given for the protection of pedestrians. Access to properties and facilities affected due to construction shall be maintained at all times.

D. The CONTRACTOR shall have the responsibility of notifying the local police, ambulance services and fire departments of daily traffic diversions.

3.2 TRAFFIC DIVERSION

A. Whenever it is necessary to divert traffic from its normal channel, such diversion shall be clearly marked by cones, drums, barricades or temporary guard rail. If the markers are left in place at night, suitable lights shall be provided and maintained.

3.3 OWNER REQUIREMENTS

A. If proper maintenance of traffic facilities and proper provision for traffic control are not being provided in accordance with local regulations and the safety of the public is thus endangered, the Contracting Officer may take the necessary steps to place them in proper condition and the cost of such services will be deducted from any payment which may be due or become due the CONTRACTOR.

B. If proper maintenance of traffic facilities and proper provision for traffic control are not being provided in accordance with local regulations and the safety of the public is thus endangered, the Contracting Officer may take the necessary steps to place them in proper condition and the cost of such services will be deducted from any payment which may be due or become due the CONTRACTOR.

END OF SECTION 344116