SECTION 21 00 00
FIRE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Provide complete automatic fire sprinkler systems to serve the new construction. One system shall serve the new education building and common areas, and the second system shall serve the new worship center. All fire protection work shall comply with the requirements of the authority having jurisdiction.

B. Fire protection system for the project is generally a "Wet-Pipe" system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by fire. Certain portions of the building (overhangs, canopies, etc.) will require a "Dry-Pipe" system employing automatic sprinklers attached to a piping system containing compressed air and connected to a water supply through a dry-pipe valve so that the air will discharge when the sprinklers are opened by fire before the water is released through the piping and sprinklers.

C. Contractor shall participate in coordination meetings with the architect and engineer to coordinate routing and layout of the sprinkler systems. The routing of the lines shall be thoroughly coordinated with the architecture to avoid access panels, exposed lines, and modified architecture.

D. Water Supply:
   1. The primary water supply for sprinklers shall be obtained from the on-site fire protection water loop. The connections shall be made at the rough-in and shall consist of all valves and equipment in accordance with the current requirements of the authority having jurisdiction.
   2. The fire protection water supply must be arranged so that water is available at all times.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, furnished specialties and accessories, each type sprinkler head, valve, piping specialty, fire protection specialty, and fire department connection specified.

B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Domestic water, storm, sanitary, and vent piping.
2. HVAC Ducts, equipment and piping.
3. Electrical conduit.
4. Items penetrating finished ceiling include but are not limited the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Fire alarm

E. Qualification Data: For qualified Installer and professional engineer.

F. Contractor shall design and prepare Shop Drawings prepared in accordance with requirements of the authority having jurisdiction\(^1\) identified as "Working Plans," including hydraulic calculations, produced by a licensed fire sprinkler designer, and which have been approved by the authority having jurisdiction\(^1\).

G. Welding certificates.

H. Fire-hydrant flow test report.

I. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

J. Field quality-control reports.

K. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals. Maintenance Data for each type sprinkler head, valve, piping specialty, fire protection specialty, and fire department connection specified, for inclusion in operating and maintenance manual specified in Division 1.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Installation of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified means experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope of this project), familiar with all precautions required, and has complied with all the requirements of the authority having jurisdiction\(^1\). Upon request, submit evidence of such qualifications to the Architect. Refer to Division-1 Section: "Definitions and Standards" for definitions for "Installers".

B. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, Specifications for Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."

C. Regulatory Requirements: Comply with the requirements of the following codes:
   2. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
   4. UL and FM Compliance: Fire protection system materials and components shall be Underwriter's Laboratories listed and labeled, and Factory Mutual approved for the application anticipated.
1.4 SEQUENCING AND SCHEDULING

A. Schedule rough-in installations with installations of other building components.

1.5 EXTRA MATERIALS

A. Valve Wrenches: Furnish to Owner, 2 valve wrenches for each type of sprinkler head installed.

B. Sprinkler Heads and Cabinets: Furnish six extra sprinkler heads of each style included in the project. Furnish each style with its own sprinkler head cabinet and special wrenches as specified in this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire protection system products which may be incorporated in the work include, but are not limited to, the following:

1. Gate Valves:
   a. Fairbanks
   b. Jenkins
   c. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
   d. Stockham

2. Swing Check Valves:
   a. Fairbanks
   b. Jenkins
   c. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
   d. Stockham

3. Grooved Mechanical Couplings:
   a. Stockham
   b. Victaulic Company of America

4. Water Flow Indicators:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Star Sprinkler Corp.
   c. Victaulic Company of America
   d. Viking Corp.

5. Hose Outlet Valves:
   a. Guardian Fire Equipment, Inc.

6. Sprinkler Heads:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Star Sprinkler Corp.
   c. Viking Corp.

2.2 PIPING AND FITTINGS:

A. All materials and equipment used in the installation of fire protection systems shall be listed as approved by UL's "List of Inspected Fire Protection Equipment and Material," FM's "Approval Guide" listed for use in sprinkler systems and shall be the latest design of the manufacturer. No substitutions unless specifically noted.
B. Overhead Pipe: All piping shall be approved for fire protection service by UL/FM and as allowed by the authority having jurisdiction.

C. Fittings: All fittings shall be cast iron, groove or welded type and shall be suitable in every way for sprinkler system purposes. No "slip-on" type fittings for plain end pipe allowed.

2.3 GENERAL DUTY VALVES

A. Gate Valves - 2 Inch and Smaller: body and bonnet of cast bronze, 175 pound cold water working pressure - non-shock, threaded ends, solid wedge, outside screw and yoke, rising stem, screw-in bonnet, and malleable iron handwheel. Valves shall be capable of being re-packed under pressure, with valve wide open.

B. Gate Valves - 2-1/2 Inch and Larger: iron body; bronze mounted, 175 pound cold water working pressure - non-shock. Valves shall have solid taper wedge; outside screw and yoke, rising stem; flanged bonnet, with body and bonnet conforming to ASTM A 126 Class B; replaceable bronze wedge facing rings; flanged ends; and a packing assembly consisting of a cast iron gland flange, brass gland, packing, bonnet, and bronze bonnet bushing. Valves shall be capable of being repacked under pressure, with valve wide open.

C. Swing Check Valves: MSS SP-71; Class 175, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

2.4 SPECIALTY VALVES

A. Alarm Check Valve: 175 psig working pressure, designed for horizontal or vertical installations, and have cast iron, flanged inlet and outlet, bronze grooved seat with "O" ring seals, single hinge pin and latch design. Provide trim sets for bypass, drain, electric sprinkler alarm switch, pressure gages, drip cup assembly piped without valves separate from main drain line, and fill line attachment with strainer.

B. Detector Check Valves: Galvanized cast iron body, with a bolted cover with air bleed device for access to internal parts; 175 psig working pressure. One piece bronze disc with bronze bushings, pivot and replaceable seat. Provide threaded bypass taps in the inlet and outlet for bypass meter connection. Valve shall be set to allow minimal water flow through the bypass meter; when major water flow is required, the water pressure will fully open the clapper.

2.5 AUTOMATIC SPRINKLERS

A. Sprinkler Heads: fusible link type, and style as required by the application.

B. Sprinkler Head Finishes: Provide heads with the following finishes:
   1. Upright and Pendant Styles: rough bronze finish for heads in unfinished spaces and not exposed to view.

C. Sprinkler Head Cabinet and Wrench: finished steel cabinet, suitable for wall mounting, with hinged cover and space for 6 spare sprinkler heads plus sprinkler head wrench. Provide a separate cabinet for each style sprinkler head on the project.
2.6 ALARM DEVICES

A. General: Types and sizes shall mate and match piping and equipment connections.

B. Water Flow Indicators: vane type waterflow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 Volts DC; complete with factory-set, field-adjustable retard element to prevent false signals, and tamper-proof cover which sends a signal when cover is removed.

C. Supervisory Switches: SPST, normally closed contacts, designed to signal valve in other than full open position.

2.7 FIRE DEPARTMENT CONNECTIONS

A. Wall Type Connections: As required per City of Terrell Fire Department requirements. Each inlet shall have a clapper valve, and plug and chain. Unit shall have wall escutcheon of cast brass, finish to match connections, with words "AUTO SPKR - FIRE DEPT CONNECTION" in raised letters.

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping mains. So far as practical, install piping as indicated.

1. Deviations from approved "Working Plans" for sprinkler piping, require written approval of the authority having jurisdiction. Written approval shall be on file with the Architect prior to deviating for the approved "Working Plans."

2. Sprinkler heads are considered an integral part of the reflected ceiling plan. The design shall be thoroughly coordinated with the architectural ceiling plan and shall be reviewed and approved by the Architect and Engineer prior to proceeding forward with installation. Deviations from approved "Working Plans" for sprinkler piping, require written approval of the authority having jurisdiction. Written approval shall be on file with the Architect prior to deviating for the approved "Working Plans."

3. Design and installation shall meet all adopted codes, NFPA 13, and FPA 14, including all standpipe requirements.

B. Install sprinkler piping to provide for system drainage in accordance with NFPA 13.

C. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions in pipes 2 inch and smaller, adjacent to each valve. Unions are not required on flanged devices or in piping installations using grooved mechanical couplings.

E. Install flanges or flange adapters on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

F. Hangers and Supports: Comply with the requirements of NFPA 13 and NFPA 14. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions,
for rigid systems. Provide protection from damage where subject to earthquake in accordance with NFPA 13.

G. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.

H. Install mechanical sleeve seal at pipe penetrations in basement and foundation walls.

I. Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

J. Install pressure gage on the riser or feed main at or near each test connection. Provide gage with a connection not less than 1/4 inch and having a soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and where they will not be subject to freezing.

3.2 PIPE JOINT CONSTRUCTION

A. Welded Joints: AWS D10.9, Level AR-3.

B. Threaded Joints: conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:
   1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be treated into joint.
   2. Align threads at point of assembly.
   3. Apply appropriate tape or thread compound to the external pipe threads.
   4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
   5. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

D. Mechanical Grooved Joints: cut or roll grooves on pipe ends dimensionally compatible with the couplings.

3.3 VALVE INSTALLATIONS

A. General: Install fire protection specialty valves, fittings, and specialties in accordance with the manufacturer's written instructions, NFPA 13 and 14, and the authority having jurisdiction.

B. Gate Valves: Install supervised-open gate valves so located to control all sources of water supply except fire department connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve.
C. Hose Outlet Valves: Install 2-1/2 inch hose outlet valves with quick-disconnect 2-1/2 inch to 1-1/2 inch reducing coupling and flow restriction device at each standpipe outlet for hose connections.

3.5 SPRINKLER HEAD INSTALLATIONS

A. Use proper tools to prevent damage during installations.

3.6 FIELD QUALITY CONTROL

A. Flush, test, and inspect sprinkler piping systems in accordance with NFPA 13.

B. Replace components which do not pass the test procedures specified, and retest repaired portion of the system.

END OF SECTION
SECTION 22 00 00
DIVISION 22 SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Related Requirements:

1. Division 01 Section "Submittal Procedures" for coordinating Division 22 submittals with other Divisions.
2. Division 01 Section "Operation and Maintenance Data" for submitting operation and maintenance manuals.
3. Division 01 Section "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
4. Division 01 Section "Demonstration and Training" for training of Owner's personnel.

1.3 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Engineer's and Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Engineer's and Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

C. File Transfer Protocol (FTP): Communications protocol that enables transfer of files to and from another computer over a network and that serves as the basis for standard Internet protocols. An FTP site is a portion of a network located outside of network firewalls within which internal and external users are able to access files.

1.4 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and Architect and additional time for handling and reviewing submittals required by those corrections.

1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.

1.5 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Engineer's Digital Data Files: Electronic digital data files of the Revit model used to produce the Contract Drawings will be provided by Engineer for Contractor's use in preparing submittals only after Engineer's Release Form has been appropriately executed.

1. Engineer will furnish Contractor one set of digital data files used to produce the Contract Drawings for use in preparing Shop Drawings and Project record drawings.
   
   a. Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to the Contract Drawings.
   c. Contractor shall execute a data licensing agreement (Engineer's Release Form) in substantial agreement with AIA Document C106, Digital Data Licensing Agreement.
   d. The Contractor agrees as a pre-condition of the use of Engineer's digital data files to provide Engineer with Contractor's final files (Record Drawings) at the completion of the project in the same software version as provided by Engineer.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for Division 22 Sections concurrently unless partial submittals are indicated on approved submittal schedule. Product data submittals and shop drawings may be submitted in separate volumes.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   
   a. Engineer and Architect reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

5. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer and Architect will advise Contractor when a submittal being processed must be delayed for coordination.
6. Resubmittal Review: One resubmittal is allowed. Additional resubmittal reviews will be performed after Engineer’s review fees have been negotiated. Allow 15 days for review of each resubmittal.
C. Paper Submittals: Paper submittals will not be allowed.

D. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
   a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-221000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-221000.01.A).
3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer and Architect.
4. Transmittal Form for Electronic Submittals: Use electronic form acceptable to Owner and Architect, containing the following information:
   a. Project name.
   b. Date.
   c. Name and address of Engineer.
   d. Name of Architect.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Names of subcontractor, manufacturer, and supplier.
   h. Category and type of submittal.
   i. Submittal purpose and description.
   j. Specification Section number and title.
   k. Specification paragraph number or drawing designation and generic name for each of multiple items.
   l. Drawing number and detail references, as appropriate.
   m. Location(s) where product is to be installed, as appropriate.
   n. Related physical samples submitted directly.
   o. Indication of full or partial submittal.
   p. Transmittal number, numbered consecutively.
   q. Submittal and transmittal distribution record.
   r. Other necessary identification.
   s. Remarks.
5. Metadata: Include the following information as keywords in the electronic submittal file metadata:
   a. Project name.
   b. Number and title of appropriate Specification Section.
   c. Manufacturer name.
   d. Product name.

E. Options: Identify options requiring selection by Engineer.

F. Deviations and Additional Information: Prepare on Contractor's letterhead, relevant information, requests for data, revisions other than those requested by Engineer on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.
G. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's and Architect's action stamp.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by Division 22 Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Submit electronic submittals via email or directly to Project Web site as PDF electronic files.

2. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.
   a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.

B. Product Data:

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:
   a. Manufacturer's catalog cuts.
   b. Manufacturer's product specifications.
   c. Standard color charts.
   d. Statement of compliance with specified referenced standards.
   e. Testing by recognized testing agency.
   f. Application of testing agency labels and seals.
   g. Notation of coordination requirements.
   h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:
   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
   d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
a. Identification of products.
b. Schedules.
c. Compliance with specified standards.
d. Notation of coordination requirements.
e. Notation of dimensions established by field measurement.
f. Relationship and attachment to adjoining construction clearly indicated.
g. Seal and signature of professional engineer if specified.

2. BIM (Revit) File Incorporation: Develop and incorporate Shop Drawing files into Building Information Model established for Project.

D. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
2. Manufacturer and product name, and model number if applicable.
3. Number and name of room or space.
4. Location within room or space.

E. Coordination Drawing Submittals: Comply with requirements specified in Division 01 Section "Project Management and Coordination."

F. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Closeout Procedures."

G. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."

H. LEED Submittals: Comply with requirements specified in Division 01 sustainable design requirements Section.

I. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.

J. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

K. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

L. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

M. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

N. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.
O. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

P. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

Q. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:

1. Name of evaluation organization.
2. Date of evaluation.
3. Time period when report is in effect.
4. Product and manufacturers' names.
5. Description of product.
6. Test procedures and results.
7. Limitations of use.

R. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

S. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

T. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer and Architect.

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01 Section "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ENGINEER’S ACTION

A. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or revisions required, and return it. Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action, as follows:
1. Engineer’s Review
   a. No Exceptions Taken: Engineer’s review found no apparent discrepancies between submittal data and requirements of Contract Documents. No further submittal review action required from Contractor.
   b. Accepted as Noted: Engineer’s review found the submittal to be in substantial conformance with the requirements of Contract Documents.
   c. Rejected: Engineer’s review found the submittal to be in non-conformance with the requirements of Contract Documents.

2. Responses required by Contractor:
   a. Confirm: Contractor will review Engineer’s notations on submittal and confirm via written response the information requested by Engineer.
   b. Revise: Contractor will review Engineer’s notations on submittal and revise submittal to comply.
   c. Resubmit: Contractor will make changes to submittal in accordance with Engineer’s notations and resubmit.

3. Additional Requirements:
   a. Requires Review and Approval by _______: In addition to Engineer’s review of submittal, the submittal must be officially submitted and approved by the authority noted.

B. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Engineer and Architect.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may be returned by the Engineer without action.

END OF SECTION
SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

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

1.3 COORDINATION
A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS
A. Description: NEMA MG 1, Design B, medium induction motor.
B. Efficiency: Energy efficient, as defined in NEMA MG 1.
C. Service Factor: 1.15.

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


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

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

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION
SECTION 22 05 17
SLEEVES AND SLEEVE SEALS 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. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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

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

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

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.
2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping 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 or Stainless steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 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 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.
C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

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

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
   4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.
3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves, Galvanized-steel wall sleeves, Galvanized-steel-pipe sleeves, or Sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves, Galvanized-steel wall sleeves, or Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, Galvanized-steel-pipe sleeves with sleeve-seal system, or Sleeve-seal fittings.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves with sleeve-seal system.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, Galvanized-steel-pipe sleeves with sleeve-seal system, or Sleeve-seal fittings.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, Galvanized-steel-pipe sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves.
   1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves, Stack-sleeve fittings or Sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:

END OF SECTION
SECTION 22 05 18
ESCUTCHEONS 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. Escutcheons.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS
A. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
B. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped steel type or split-plate, stamped-steel with concealed hinge.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.


3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 22 05 18
SECTION 22 05 19
METERS AND GAGES 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. Thermometers.
   2. Gages.
   3. Test plugs.
B. Related Sections:
   1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
   2. Meters and Gauges furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other sections.

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

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS
A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
B. Case: Brass, 7 inches long.
C. Tube: Red or blue reading, mercury filled, with magnifying lens.
D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAGES

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

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
4. Palmer - Wahl Instruments Inc.

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

1. Case: Liquid-filled type, drawn steel or brass, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Window: Glass.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

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

2.4 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.

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

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

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for air, oil, gas, and water service at 20 to 200 deg F shall be CR.

E. Test Kit: Furnish one test kit containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
   1. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install thermometers in the inlet and outlet of each domestic, hot-water storage tank.

B. Provide the following temperature ranges for thermometers:
   1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
   2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install pressure gages for discharge of each pressure-reducing valve.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket in vertical position in piping tees where thermometers are indicated.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install remote-mounting pressure gages on panel.

E. Install needle-valve and snubber fitting in piping for each pressure gage.

F. Install test plugs in tees in piping.
G. Install permanent indicators on walls or brackets in accessible and readable positions.

H. Install connection fittings for attachment to portable indicators in accessible locations.

I. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

J. Adjust faces of thermometers and gages to proper angle for best visibility.

K. Install test plugs adjacent to each temperature and pressure sensor for sensor testing and calibration.

END OF SECTION
SECTION 22 05 23
GENERAL-DUTY VALVES 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. Bronze angle valves.
   2. Brass ball valves.
   3. Bronze ball valves.
   4. Bronze check valves.

B. Related Sections:
   1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

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

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
   4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug-valve head.
   5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
   1. Gate Valves: With rising stem.
   2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
F. Valve-End Connections:

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

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

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

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. Hammond Valve.
   b. Milwaukee Valve Company.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:

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 Valve, Inc.
   b. NIBCO INC.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 150, Bronze Angle Valves with Bronze Disc:
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. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

D. Class 150, Bronze Angle Valves with Nonmetallic Disc:

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. Crane Co.; Crane Valve Group; Crane Valves.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Powell Valves.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.3 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

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. Crane Co.; Crane Valve Group; Crane Valves.
   c. Hammond Valve.
   d. Jamesbury; a subsidiary of Metso Automation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
2.4 BRONZE BALL VALVES

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

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 Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Hammond Valve.
   e. Lance Valves; a division of Advanced Thermal Systems, Inc.
   f. Legend Valve.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Red-White Valve Corporation.
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

2.5 BRONZE LIFT CHECK VALVES

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

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. Crane Co.; Crane Valve Group; Crane Valves.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
e. Ends: Threaded.
f. Disc: Bronze.
B. Class 125, Lift Check Valves with Nonmetallic Disc:

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. Flo Fab Inc.
   b. Hammond Valve.
   c. Kitz Corporation.
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty; a division of SPX Corporation.
   f. NIBCO INC.
   g. Red-White Valve Corporation.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   e. Ends: Threaded.
   f. Disc: NBR, PTFE, or TFE.

2.6 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

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 Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Red-White Valve Corporation.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.
PART 3 - EXECUTION

3.1 EXAMINATION

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

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

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball valves.
4. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Grooved-End Copper Tubing: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:

1. Bronze Ball Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125 bronze disc.

END OF SECTION
SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Pipe stands.
6. Pipe positioning systems.
7. Equipment supports.

B. Related Sections:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 fire-suppression piping Sections for pipe hangers for fire-suppression piping.
3. Division 22 Section "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7

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

1.5 SUBMITTALS

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

B. Shop Drawings. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Structural Steel 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.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.5 PIPE STANDS

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

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.
2.7 EQUIPMENT SUPPORTS
A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS
A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION
3.1 HANGER AND SUPPORT INSTALLATION
A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
E. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
   3. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
F. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 22 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.
G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Use thermal-hanger shield insert with clamp sized to match OD of insert.
      b. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
   6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

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

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

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

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. **Welded-Steel Brackets**: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   
a. Light (MSS Type 31): 750 lb.
b. Medium (MSS Type 32): 1500 lb.
c. Heavy (MSS Type 33): 3000 lb.

13. **Side-Beam Brackets** (MSS Type 34): For sides of steel or wooden beams.
14. **Plate Lugs** (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. **Horizontal Travelers** (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

**N. Saddles and Shields**: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel-Pipe-Covering Protection Saddles** (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. **Protection Shields** (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. **Thermal-Hanger Shield Inserts**: For supporting insulated pipe.

**O. Spring Hangers and Supports**: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Restraint-Control Devices** (MSS Type 47): Where indicated to control piping movement.
2. **Spring Cushions** (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. **Spring-Cushion Roll Hangers** (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. **Spring Sway Braces** (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. **Variable-Spring Hangers** (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. **Variable-Spring Base Supports** (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. **Variable-Spring Trapeze Hangers** (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. **Constant Supports**: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   
a. **Horizontal** (MSS Type 54): Mounted horizontally.
b. **Vertical** (MSS Type 55): Mounted vertically.
c. **Trapeze** (MSS Type 56): Two vertical-type supports and one trapeze member.

**P. Comply with MSS SP-69** for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

**Q. Comply with MFMA-103** for metal framing system selections and applications that are not specified in piping system Sections.

**R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.**
S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION
SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

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

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

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

1.4 COORDINATION
A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS
A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

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

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Red

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

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

B. General Requirements for Manufactured Pipe Labels installed in return air plenums: Pipe labels installed in return plenums shall meet the required flame/smoke spread rating required to be plenum rated.
C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

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

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

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch, Stainless steel, 0.025-inch, Aluminum, 0.032-inch, or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches minimum.
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

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 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.
3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. Facing down or toward easiest area of view.

C. Pipe Label Color Schedule:

1. Colors shall be according to ASME A13.1.

D. Install tags on valves and control devices in piping systems, except valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

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

1. Valve-Tag Size and Shape:

2. Valve-Tag Color:
   a. Cold Water: Green.
   b. Hot Water: Orange.

3. Letter Color:

3.4 WARNING-TAG INSTALLATION

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

END OF SECTION
SECTION 22 07 19
PLUMBING PIPING INSULATION

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. Insulation Materials:
   a. Flexible elastomeric.
   b. Mineral fiber.
   c. Polyolefin.

2. Insulating cements.
3. Adhesives.
5. Lagging adhesives.
7. Factory-applied jackets.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner angles.

B. Related Sections include the following:

1. Division 23 Section "HVAC Insulation."

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. LEED Submittal:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

C. Shop Drawings:

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

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Preformed Pipe Insulation:
   1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.2 INSULATING CEMENTS


2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
   1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
E. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a low VOC content meeting the requirements of LEED according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use mastics that have a low VOC content meeting the requirements of LEED according to 40 CFR 59, Subpart D (EPA Method 24).
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.


C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for equipment and pipe.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

   a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
   1) Same material, finish, and thickness as jacket.
   2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
   3) Tee covers.
   4) Flange and union covers.
   5) End caps.
   6) Beveled collars.
   7) Valve covers.
   8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.12 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
   2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      b. Spindle: Copper- or zinc-coated, low carbon steel or Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Copper- or zinc-coated, low carbon steel or Aluminum, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.13 CORNER ANGLES

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

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

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

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.
3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

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

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07 Section "Penetration Firestopping and fire-resistant joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels,
and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.9 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of polyolefin pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

3.11 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

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

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
D. Do not field paint aluminum or stainless-steel jackets.

3.12 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Domestic hot-water pump insulation shall be one of the following:
   1. Cellular Glass: 2 inches thick.
   2. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS 1 and Smaller: Insulation shall be one of the following:
      b. Flexible Elastomeric: 1/2 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
      d. Polyolefin: 1/2 inch thick.
   2. NPS 1-1/4 and Larger: Insulation shall be one of the following:
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
      d. Polyolefin: 1 inch thick.

B. Domestic Recirculated Hot Water:
   1. Insulation shall be one of the following:
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
      d. Polyolefin: 1 inch thick.

C. Domestic Hot (non-Recirculated) Hot Water:
1. Insulation shall be one of the following:
   b. Flexible Elastomeric: 3/4 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   d. Polyolefin: 3/4 inch thick.

D. Domestic Chilled Water (Potable):
1. All Pipe Sizes: Insulation shall be one of the following:
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   d. Polyolefin: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:
1. All Pipe Sizes: Insulation shall be one of the following:
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   d. Polyolefin: 1 inch thick.

F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1/2 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   c. Polyolefin: 1/2 inch thick.

G. Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
   b. Flexible Elastomeric: 3/4 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   d. Polyolefin: 3/4 inch thick.

H. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
   b. Flexible Elastomeric: 3/4 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   d. Polyolefin: 3/4 inch thick.
3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:
   1. Aluminum, Smooth: 0.024 inch thick.
   2. Stainless Steel, Type 304 or 316, Smooth 2B Finish: 0.020 inch thick.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Smooth: 0.024 inch thick.
   2. Stainless Steel, Type 304 or 316, Smooth 2B Finish: 0.020 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Aluminum, Smooth: 0.032 inch thick.
   2. Stainless Steel, Type 304 or 316, Smooth, with: 0.024 inch thick.
   3. <Insert jacket type.>

END OF SECTION
SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Encasement for piping.
   4. Flexible connectors.

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.

1.3 SUBMITTALS

A. Product Data: For the following products:
   1. Specialty valves.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Flexible connectors.
   5. Backflow preventers and vacuum breakers.
   6. Water penetration systems.


C. Coordination Drawings: For piping project, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Fire-suppression-water piping.
   2. Domestic water piping.
   3. HVAC hydronic piping.
   4. Lighting
   5. HVAC Duct Systems

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking “NSF-pw” on piping.

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

1.5 PROJECT CONDITIONS

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

1. Notify Architect no fewer than five days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Owner’s written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping 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 and ASTM B 88, Type M water tube, drawn temper.

4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Copper Pressure-Seal-Joint Fittings (equal to Pro Press):
   a. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
   b. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
6. Copper Push-on-Joint Fittings:
   a. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.
7. Copper-Tube Extruded-Tee Connections:
   a. Description: Tee formed in copper tube according to ASTM F 2014.
   b. NOTE: Copper-Tube Extruded-Tee Connections may only be used if separately approved in writing from Engineer.
8. Grooved-Joint Copper-Tube Appurtenances:
a. Copper Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
b. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.
   2. Copper Pressure-Seal-Joint Fittings:
      a. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      b. NPS 3 and NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 PVC PIPE AND FITTINGS

   2. PVC Schedule 80 Threaded Fittings: ASTM D 2464.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

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

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

E. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
   1. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
2.5 ENCASEMENT FOR PIPING

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

2.6 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.
B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.7 TRANSITION FITTINGS

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

2.8 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 Flanges:

1. Description:
   a. Factory-fabricated, bolted, companion-flange assembly.
   b. Pressure Rating: 150 psig minimum.
   c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

E. 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.

F. 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.

2.9 FLEXIBLE CONNECTORS

A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

B. 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.
PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 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 underground copper tube in PE encasement according to ASTM A 674 or AWWA C105.

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

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

H. Install domestic water piping level and plumb.

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

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

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

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

M. Install piping to permit valve servicing.

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

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.
Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

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

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

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

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

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

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.
H. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

I. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.

J. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

K. Steel-Piping Grooved Joints: Cut or roll groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

L. 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.

M. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Piping: Join according to ASTM D 2855.

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

3.4 VALVE INSTALLATION

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

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

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.
3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. NPS 2 and Larger: Sleeve-type coupling.

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

3.6 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings, unions or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4. Use dielectric flanges, flange kits, or nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.7 FLEXIBLE CONNECTOR INSTALLATION

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

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

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

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. 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 3/8 inch.
E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

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

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

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

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

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

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

1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.
5. NPS 8: 48 inches with 7/8-inch rod.

J. Install supports for vertical PVC piping every 48 inches.

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

3.9 CONNECTIONS

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

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

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

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

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

3.11 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.

3.12 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.13 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 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 PIPING SCHEDULE

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

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: If contractor wishes to use extruded-tee connections and brazed joints on aboveground copper tubing, contractor shall submit a request, in writing, to the engineer. The engineer will review the request and instruct accordingly. This section is not a guarantee that the request will be approved.

D. Under-building-slab, domestic water, building service piping, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed copper pressure-seal fittings; and pressure-sealed joints.
   2. PVC, Schedule 40 pipe; PVC, Schedule 40 socket fittings; and solvent-cemented joints.

E. Aboveground domestic water piping, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and brazed joints.
   2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
   3. Hard copper tube, ASTM B 88, Type L; copper push-on-joint fittings; and push-on joints.
   4. PVC will not be accepted.

3.15 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
SECTION 22 11 19
DOMESTIC WATER 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 domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated water mixing valves.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Post hydrants.
11. Drain valves.
12. Water hammer arresters.
13. Air vents.
15. Trap-seal primer systems.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbi ng Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Domestic Water Piping" for water meters.
3. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

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

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
1.5 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. 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:
   2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Inlet and Outlet Connections: Threaded.
   5. Finish: Rough bronze or Chrome plated.

B. Hose-Connection Vacuum Breakers:
   2. Body: Bronze, nonremovable, with manual drain.
   4. Finish: Chrome, nickel plated, or Rough bronze.

C. Pressure Vacuum Breakers:
   2. Operation: Continuous-pressure applications.
   3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   4. Accessories:
      a. Valves: Ball type, on inlet and outlet.

D. Spill-Resistant Vacuum Breakers:
   2. Operation: Continuous-pressure applications.
   3. Accessories:
      a. Valves: Ball type, on inlet and outlet.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
5. Finish: Chrome plated or Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers:
   2. Operation: Continuous-pressure applications.
   3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger, unless specifically scheduled otherwise.
   5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   6. 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. Double-Check Backflow-Prevention Assemblies:
   2. Operation: Continuous-pressure applications, unless otherwise indicated.
   3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   6. 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.

D. Beverage-Dispensing-Equipment Backflow Preventers:
   2. Operation: Continuous-pressure applications.
   4. End Connections: Threaded.

E. Dual-Check-Valve Backflow Preventers:
   2. Operation: Continuous-pressure applications.

F. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:
   2. Operation: Continuous-pressure applications.
   4. End Connections: Threaded.

G. Double-Check, Detector-Assembly Backflow Preventers:
1. Standard: ASSE 1048 and FMG approved or UL listed.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
4. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved.
5. End Connections: Flanged.
6. Accessories:
   a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
   b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

H. Hose-Connection Backflow Preventers:
2. Operation: Up to 10-foot head of water back pressure.
3. Inlet Size: NPS 1/2 or NPS 3/4.
5. Capacity: At least 3-gpm flow.

I. Backflow-Preventer Test Kits:
1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
2. Pressure Rating: Initial working pressure of 150 psig.
3. 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.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Control Valves:
1. Description: Pilot-operation, diaphragm-type, single-seated main water control valve.
2. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
3. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.4 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:
1. Type: Ball valve with two readout ports and memory setting indicator.
2. Body: Brass or bronze,
3. Size: Same as connected piping, but not larger than NPS 2.
4. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
C. Memory-Stop Balancing Valves:

2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 2 or smaller.
4. Body: Copper alloy.
5. Port: Standard or full port.
7. Seats and Seals: Replaceable.
8. End Connections: Solder joint or threaded.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

3. Type: Thermostatically controlled water mixing valve.
5. Connections: Threaded inlets and outlet.
6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Finish: Chrome plated or Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

3. Type: Exposed-mounting or cabinet-type, thermostatically controlled water mixing valve.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
8. Valve Finish: Chrome plated, Polished, chrome plated or Rough bronze.
9. Piping Finish: Chrome plated or Copper.

C. Manifold, Thermostatic, Water-Mixing-Valve Assemblies:

2. Large-Flow Parallel: Thermostatic water mixing valve and downstream pressure regulator with pressure gages on inlet and outlet.
5. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.
6. Water Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.
7. Component Pressure Ratings: 125 psig minimum, unless otherwise indicated.
8. Thermostatic Mixing Valve and Water Regulator Finish: Chrome plated, Polished, chrome plated, or Rough bronze.
9. Piping Finish: Chrome plated or Copper.
D. Individual-Fixture, Water Tempering Valves:
   2. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   5. Inlets and Outlet: Threaded.
   6. Finish: Rough or chrome-plated bronze.

2.6 STRainers for Domestic water piping

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Perforation Size:
      a. Strainers NPS 2 and Smaller: 0.020 inch.
      b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
      c. Strainers NPS 5 and Larger: 0.10 inch.

2.7 OUTLET BOXES

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

B. Icemaker Outlet Boxes:
   1. Mounting: Recessed.
   2. Material and Finish: Enameled-steel or epoxy-painted-steel or plastic box and faceplate.
   3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
   4. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.8 HOSE BIBBS

A. Hose Bibbs:
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze, Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed or exposed-outlet, as scheduled, self-draining wall hydrants.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounting with cover.
8. Box and Cover Finish: As scheduled.
10. Nozzle and Wall-Plate Finish: As scheduled.
11. Operating Key(s): Two with each wall hydrant.

2.10 POST HYDRANTS

A. Nonfreeze, Draining-Type Post Hydrants:

1. Type: Nonfreeze, exposed-outlet post hydrant.
2. Operation: Loose key.
3. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
7. Drain: Designed with hole to drain into ground when shut off.
8. Vacuum Breaker: Nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052; and garden-hose thread complying with ASME B1.20.7 on outlet.
9. Operating Key(s): Two with each loose-key-operation wall hydrant.

2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

B. Gate-Valve-Type, Hose-End Drain Valves:
2. Pressure Rating: Class 125.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:
1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
5. Drain: NPS 1/8 side outlet with cap.

2.12 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
2. Type: Copper tube with piston.
3. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.13 AIR VENTS

A. Bolted-Construction Automatic Air Vents:
1. Body: Bronze.
2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
5. Size: NPS 1/2 minimum inlet.

B. Welded-Construction Automatic Air Vents:
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
2.14  TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:
   4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
   5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
   6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Valves:
   2. Size: NPS 1-1/4 minimum.

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 pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

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

D. Install water control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

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

F. 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.

G. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
H. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

I. Install draining-type post hydrants with 1 cu. yd of crushed gravel around drain hole where installations are on ground. Set post hydrants in concrete paving.

J. Install freeze-resistant yard hydrants with riser pipe set in concrete or pavement. Do not encase canister in concrete.

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

L. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

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

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

O. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

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

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

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

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
5. Carbonated-beverage-machine backflow preventers.
7. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
10. Calibrated balancing valves.
11. Primary, thermostatic, water mixing valves.
13. Outlet boxes.
15. Supply-type, trap-seal primer valves.
B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section “Identification for Plumbing Piping and Equipment.”

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
   1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device’s reference standard.

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

3.5 ADJUSTING

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

B. Set field-adjustable flow set points of balancing valves.

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

END OF SECTION
SECTION 22 13 16
SANITARY WASTE AND VENT 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. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.
B. Related Sections:
   1. Division 22 Section "Sanitary Sewerage Pumps" for effluent and sewage pumps.

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

1.4 SUBMITTALS
A. Product Data: For each type of product indicated.
B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
C. Field quality-control reports.

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

1.6 PROJECT CONDITIONS
A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Owner’s written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Pipe and fittings shall be produced and manufactured domestically. Pipe and fittings that are produced internationally may be considered for approval if approved in writing by the authorities having jurisdiction. If contractor wishes to submit on pipe and fittings that are produced internationally, contractor shall provide the written letter from the AHJ to the engineer as well as provide additional items that may be requested by the engineer.

B. CISPI, Hubless-Piping Couplings:


2. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Cast-Iron, Hubless-Piping Couplings:


2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.


C. Steel Pipe Pressure Fittings:


D. Cast-Iron Flanges: ASME B16.1, Class 125.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

E. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
   2. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.5 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

E. Copper Pressure Fittings:
   2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.6 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.
   1. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
E. Solvent Cement: ASTM D 2564.

1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.

2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

3. Unshielded, Nonpressure Transition Couplings:

   b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. Sleeve Materials:
      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

5. Pressure Transition Couplings:

   b. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   c. Center-Sleeve Material: Manufacturer's standard.
   d. Gasket Material: Natural or synthetic rubber.
   e. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

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

2. Dielectric Unions:

   a. Description:
      1) Standard: ASSE 1079.
      2) Pressure Rating: 125 psig minimum at 180 deg F.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.
3. Dielectric Flanges:
   a. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 125 psig minimum at 180 deg F.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:
   a. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 150 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.
      5) Washers: Phenolic with steel backing washers.

5. Dielectric Nipples:
   a. Description:
      1) Electroplated steel nipple complying with ASTM F 1545.
      2) Pressure Rating: 300 psig at 225 deg F.
      3) End Connections: Male threaded or grooved.
      4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING
   A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31 Section "Earth Moving."

3.2 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 coordination drawings.

   B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

   D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

   E. Install piping to permit valve servicing.

   F. Install piping at indicated slopes.
G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. 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.

L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Drain: 1/4 inch per foot downward in direction of flow for piping NPS 2 and smaller; 1/4 inch per foot downward in direction of flow for piping NPS 3 and larger.
   2. Vent Piping: Slope down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping according to CISPI’s "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

N. Install steel piping according to applicable plumbing code.

O. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.

P. Install aboveground copper tubing according to CDA’s "Copper Tube Handbook."

Q. Install aboveground ABS piping according to ASTM D 2661.

R. Install aboveground PVC piping according to ASTM D 2665.

S. Install underground PVC piping according to ASTM D 2321.

T. Install engineered soil and waste drainage and vent piping systems as follows:

U. Install underground, copper, force-main tubing according to CDA’s "Copper Tube Handbook."

V. Plumbing Specialties:
   1. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Sanitary Waste Piping Specialties."
   2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with
3. Closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."

3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."

W. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION


C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

F. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

G. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

I. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves:
   1. Install shutoff valve on each sewage pump discharge.
   2. Install gate or full-port ball valve for piping NPS 2 and smaller.
   3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

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

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   3. Vertical Piping: MSS Type 8 or Type 42, clamps.
   4. Install individual, straight, horizontal piping runs:
      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.
   5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   6. Base of Vertical Piping: MSS Type 52, spring hangers.
B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

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

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

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to
   60 inches.

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

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

1. NPS 1-1/4: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.

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

I. Install supports for vertical stainless-steel piping every 10 feet.

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

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

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

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

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for backwater valves, cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
6. 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.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.9 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 or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

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.

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

3.11 PIPING SCHEDULE

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

B. Aboveground, soil and waste piping any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
4. Copper DWV tube, copper drainage fittings, and soldered joints.

C. Aboveground, vent piping shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
   4. Copper DWV tube, copper drainage fittings, and soldered joints.
      a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.

D. Underground, soil, waste, and vent piping shall be any of the following:
   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
   2. Hubless, cast-iron soil pipe and fittings; CISPI cast-iron hubless-piping couplings; and coupled joints.
   3. PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION
SECTION 22 13 19
SANITARY WASTE 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 sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Trench drains.
   4. Channel drainage systems.
   5. Through-penetration firestop assemblies.
   7. Flashing materials.
B. Related Sections include the following:
   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
   2. Division 22 Section "Plumbing Fixtures" for hair interceptors.

1.3 DEFINITIONS
B. FRP: Fiberglass-reinforced plastic.
C. HDPE: High-density polyethylene plastic.
D. PE: Polyethylene plastic.
E. PP: Polypropylene plastic.
F. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.
1.5 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


1.6 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:

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:

   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast iron, ASME A112.3.1 for stainless steel for cleanout test tee.

3. Size: Same as connected drainage piping


5. Closure: Countersunk, brass plug.

6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

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:

   b. MIFAB, Inc.
   d. Watts Drainage Products Inc.
   e. Zurn Plumbing Products Group
2. Standard: ASME A112.6.3.
5. Top or Strainer Material: Nickel bronze.

2.3 TRENCH DRAINS

A. Trench Drains:

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:
   b. MIFAB, Inc.
   d. Watts Drainage Products Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Material: Ductile or gray iron.
2.4 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:
   a. ProSet Systems Inc.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.

3. Size: Same as connected soil, waste, or vent stack.

4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.

2. Size: Same as connected waste piping.
   a. NPS 2: 4-inch- minimum water seal.
   b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

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

1. Description: Cast iron, with threaded inlet and spigot outlet, and trap-seal primer valve connection.

2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.

2. Body: Bronze or cast iron.

3. Inlet: Opening in top of body.

4. Outlet: Larger than inlet.

5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.

2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

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

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

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

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

2.6 FLASHING MATERIALS

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

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Applications: 12 oz./sq. ft. thickness.
   2. Vent Pipe Flashing: 8 oz./sq. ft. thickness.

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


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

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

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

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.
PART 3 - EXECUTION

3.1 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 floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
   3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

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

H. Install through-penetration firestop assemblies in plastic conductor and stacks at floor penetrations.

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 expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

O. Install wood-blocking reinforcement for wall-mounting-type specialties.

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

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

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

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. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
F. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. 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 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 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
SECTION 22 14 13
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. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty 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.
   2. Storm Drainage, Force-Main Piping: 100 psig.

1.4 SUBMITTALS

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

B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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


1.6 PROJECT CONDITIONS

A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect no fewer than five days in advance of proposed interruption of storm-drainage service.
2. Do not proceed with interruption of storm-drainage service without Owner’s written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service classes.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.
   1. Pipe and fittings shall be produced and manufactured domestically. Pipe and fittings that are produced internationally may be considered for approval if approved in writing by the authorities having jurisdiction. If contractor wishes to submit on pipe and fittings that are produced internationally, contractor shall provide the written letter from the AHJ to the engineer as well as provide additional items that may be requested by the engineer.

B. CISPI, Hubless-Piping Couplings:
   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. MIFAB, Inc.
      b. Tyler Pipe.
   3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.


C. Steel-Pipe Pressure Fittings:

D. Cast-Iron Flanges: ASME B16.1, Class 125.
1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

E. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:

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. Victaulic Company.


3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.5 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.

D. Copper Pressure Fittings:
   2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.6 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.
   1. Use adhesive primer that has a VOC content of 550 g/L or less when calculated.
according to 40 CFR 59, Subpart D (EPA Method 24).

E. Solvent Cement: ASTM D 2564.

1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.

2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.

3. Unshielded, Nonpressure Transition Couplings:

   b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. Sleeve Materials:

      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

5. Pressure Transition Couplings:

   b. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
   c. Center-Sleeve Material: Manufacturer's standard.
   d. Gasket Material: Natural or synthetic rubber.
   e. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

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

2. Dielectric Unions:

   a. Description:

      1) Standard: ASSE 1079.
      2) Pressure Rating: 150 psig at 180 deg F.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.
3. Dielectric Flanges:
   a. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 150 psig minimum.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:
   a. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 150 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.

5. Dielectric Nipples:
   a. Description:
      1) Electroplated steel nipple complying with ASTM F 1545.
      2) Pressure Rating: 300 psig at 225 deg F.
      3) End Connections: Male threaded or grooved.
      4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING
   A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31 Section "Earth Moving."

3.2 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 from layout are approved on coordination drawings.

   B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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

   D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

   E. Install piping to permit valve servicing.

   F. Install piping at indicated slopes.
G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
   1. Building Storm Drain: 1/4 inch per foot downward in direction of flow.
   2. Horizontal Storm-Drainage Piping: 1/4 inch per foot downward in direction of flow.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

N. Install steel piping according to applicable plumbing code.

O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

P. Install aboveground ABS piping according to ASTM D 2661.

Q. Install aboveground PVC piping according to ASTM D 2665.

R. Install underground PVC piping according to ASTM D 2321.

S. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

T. Install force mains at elevations indicated.

U. Plumbing Specialties:
   1. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Storm Drainage Piping Specialties."
   2. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Storm Drainage Piping Specialties."
   3. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Storm Drainage Piping Specialties."

V. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements
for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION


D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

H. Plastic, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: nonpressure transition couplings.
4. In Underground Force-Main Piping:
   a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
   b. NPS 2 and Larger: Pressure transition couplings.

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

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
   2. Install backwater valves in accessible locations.
   3. Comply with requirements for backwater valves specified in Division 22 Section "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

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

   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Individual, Straight, Horizontal Piping Runs:
      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.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

C. Support vertical piping and tubing at base and at each floor.
D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

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

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

1. NPS 1-1/4: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.

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

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

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

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

K. Support piping and tubing not listed above 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.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit
cover flush with floor.

3. Comply with requirements for backwater valves, cleanouts, and, drains specified in Division 22 Section "Storm Drainage Piping Specialties."

D. Connect force-main piping to the following:

1. Sump Pumps: To sump pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.9 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 until 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.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 CLEANING

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

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
B. Aboveground storm drainage piping NPS 15 and smaller shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI, hubless-piping couplings; and coupled joints.
C. Underground storm drainage piping NPS 15 and smaller shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. PVC pipe, PVC socket fittings, and solvent-cemented joints.
D. Aboveground storm drainage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
   1. Hard copper tube, copper pressure fittings, and soldered joints.
   2. Galvanized-steel pipe, pressure fittings, and threaded joints.
E. Aboveground storm drainage force mains NPS 2-1/2 to NPS 6 shall be any of the following:
   1. Hard copper tube, copper pressure fittings, and soldered joints.
   2. Galvanized-steel pipe, pressure fittings, and threaded joints.
   3. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
   4. Fitting-type transition couplings if dissimilar pipe materials.

END OF SECTION
SECTION 22 34 00
FUEL-FIRED, DOMESTIC-WATER HEATERS

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. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
      2. Domestic-water heater accessories.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type and size of domestic-water heater 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. Product Certificates: For each type of commercial, gas-fired, domestic-water heater, from
      manufacturer.
   B. Source quality-control reports.
   C. Field quality-control reports.
   D. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters 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. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

C. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.7 COORDINATION

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

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures including storage tank and supports.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

   a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:

      1) Storage Tank: Five years.
      2) Controls and Other Components: Two year(s).

   b. Compression Tanks: Five years.
PART 2 - PRODUCTS

2.1 Domestic-Water Heaters

A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Lochinvar, LLC.
   b. PVI Industries, LLC.
   c. Rheem Manufacturing Company.
   e. State Industries.


3. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.

   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
   b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

5. Factory-Installed Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
   e. Jacket: Steel with enameled finish.
   f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
   g. Temperature Control: Adjustable thermostat.
   h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
   i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
   1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   2. Construction:
      a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Air-Charging Valve: Factory installed.
   3. Capacity and Characteristics:

B. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
   1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."


D. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 5-psig pressure rating as required to match gas supply.

E. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."
1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.

B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

C. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters 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 outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

G. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

I. Fill domestic-water heaters with water.

J. Charge domestic-water compression tanks with air.
3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."

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

D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

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 heaters 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. Train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters.

END OF SECTION 22 34 00
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 conventional plumbing fixtures and related components:

1. Faucets for lavatories, showers and sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Interceptors.
7. Dishwasher air-gap fittings.
8. Disposers.
10. Urinals.
11. Lavatories.

B. Related Sections include the following:

1. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
2. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS


B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. LEED Submittal:

1. Product Data for Credit WE [2] [3.1] [3.2] [2 and 3.1] [2, 3.1, and 3.2]: Documentation indicating flow and water consumption requirements.

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

D. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
3. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
7. Stainless-Steel Residential Sinks: ASME A112.19.3.
8. Vitreous-China Fixtures: ASME A112.19.2M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
5. Hose-Connection Vacuum Breakers: ASSE 1011.

I. Comply with the following applicable standards and other requirements specified for bathtub bathtub/shower and shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

2. Brass and Copper Supplies: ASME A112.18.1.

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

1. Disposers: ASSE 1008 and UL 430.
4. Floor Drains: ASME A112.6.3.
5. Grab Bars: ASTM F 446.
8. Off-Floor Fixture Supports: ASME A112.6.1M.

1.6 WARRANTY

1. Warranty Period for Commercial Applications: Three year(s) from date of Substantial Completion.

1.7 EXTRA MATERIALS

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

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

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Standard Companies, Inc.
   b. Chicago Faucets.
   c. Elkay Manufacturing Co.
   d. Just Manufacturing Company.
   e. Kohler Co.
   f. Speakman Company.
   g. Zurn Plumbing Products Group

2. Description: Single-control mixing and/or Two-handle mixing valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. Body Material: General-duty, solid brass or copper or brass underbody with brass cover plate.
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 2.2 gpm.
d. Centers: As noted in schedule.
e. Valve Handle(s): As noted in schedule.
f. Inlet(s): NPS 3/8 tubing
g. Spout: Rigid type.
h. Spout Outlet: Aerator
i. Operation: As noted in schedule.
j. Drain: Grid
k. Tempering Device: As noted in schedule or on drawings.

2.2 SHOWER FAUCETS

A. Shower Faucets

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Chicago Faucets.
   b. Grohe America, Inc.
   c. Lawler Manufacturing Co., Inc.
   d. T & S Brass and Bronze Works, Inc.

2. Description: Single-handle thermostatic and pressure-balance valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.

2.3 SINK FAUCETS

A. Sink Faucets

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Standard Companies, Inc.
   b. Chicago Faucets.
   c. Elkay Manufacturing Co.
   d. Just Manufacturing Company.
   e. Kohler Co.
   f. Speakman Company.
   g. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: As noted in schedule. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 2.5 gpm, unless otherwise indicated.
   d. Mixing Valve: Two-lever handle.
   e. Backflow Protection Device for Side Spray: Required.
   f. Centers: As noted in schedule.
g. Handle(s): As noted in schedule.
h. Inlet(s): NPS 3/8 tubing
i. Spout Type: As noted in schedule.
j. Spout Outlet: Aerator.
k. Operation: As noted in schedule.
l. Drain: As noted in schedule.

2.4 FLUSHOMETERS

A. Flushometers

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

   a. Sloan Valve Company.
   b. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Flushometer for urinal or water-closet-type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.

2.5 TOILET SEATS

A. Toilet Seats

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

   a. American Standard Companies, Inc.
   b. Church Seats.
   c. Eljer.
   d. Kohler Co.

2. Description: Toilet seat for water-closet-type fixture.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers

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

   a. Engineered Brass Co.
   b. McGuire Manufacturing Co., Inc.
   c. Plumberex Specialty Products Inc.
   d. TRUEBRO, Inc.
   e. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
B. Protective Shielding Piping Enclosures

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

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.7 FIXTURE SUPPORTS

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. Josam Company.
2. MIFAB Manufacturing Inc.
5. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports

1. Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

D. Lavatory Supports

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

E. Sink Supports

1. Description: Type II, sink carrier with hanger plate, bearing studs, and tie rod for sink-type fixture. Include steel uprights with feet.

2.8 DISHWASHER AIR-GAP FITTINGS

A. Dishwasher Air-Gap Fittings

1. Description: Fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body; chrome-plated brass cover; and capacity of at least 5 gpm; and inlet
pressure of at least 5 psig at a temperature of at least 140 deg F. Include 5/8-inch- ID inlet and 7/8-inch- ID outlet hose connections.

2. Hoses: Rubber and suitable for temperature of at least 140 deg F.

2.9 WATER CLOSETS

A. Water Closets

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Eljer.
   d. Kohler Co.
   e. TOTO USA, Inc.

2.10 URINALS

A. Urinals

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Kohler Co.
   d. TOTO USA, Inc.

2.11 LAVATORIES

A. Lavatories

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Kohler Co.
   d. TOTO USA, Inc.

2.12 KITCHEN SINKS

A. Kitchen Sinks

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Elkay Manufacturing Co.
   b. Just Manufacturing Company.
   c. Kohler Co.
   d. Moen, Inc.
PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers’ written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

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

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

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

R. Install shower flow-control fittings with specified maximum flow rates in shower arms.

S. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

T. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

U. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install on countertop at sink. Connect inlet hose to dishwasher and outlet hose to disposer.

V. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

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

3.3 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

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

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

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

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

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

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

E. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION
SECTION 22 47 00
DRINKING FOUNTAINS AND WATER COOLERS

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 drinking fountains and water coolers and related components:
   1. Drinking fountains.
   2. Pressure water coolers.
   4. Fixture supports.

1.3 DEFINITIONS
A. Accessible Drinking Fountain or Water Cooler: Fixture that can be approached and used by people with disabilities.
B. Cast Polymer: Dense, cast-filled-polymer plastic.
C. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.
D. Fitting: Device that controls flow of water into or out of fixture.
E. Fixture: Drinking fountain or water cooler unless one is specifically indicated.
F. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.
G. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS
A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For fixtures 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.


C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.


F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 DRINKING FOUNTAINS

A. Drinking Fountains, :

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

   a. Elkay Manufacturing Co.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Oasis Corporation.

2. Description: Accessible, wall-mounting drinking fountain.

   a. Material: As scheduled.
   c. Bubblers: One, with adjustable stream regulator, located on deck.
   d. Control: Push bar.
   e. Supply: NPS 3/8 with ball, gate, or globe valve.
   f. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
   g. Support: Type I, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 PRESSURE WATER COOLERS

A. Water Coolers:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Elkay Manufacturing Co.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Oasis Corporation.

2. Description: ARI 1010, pressure with bubbler water cooler.
   a. Cabinet: As scheduled
   b. Bubbler: One, with adjustable stream regulator, located on deck.
   c. Control: Push button.
   d. Supply: NPS 3/8 with ball, gate, or globe valve.
   e. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
   f. Cooling System: Electric, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

   1) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.

2.3 REMOTE WATER COOLERS

A. Water Coolers, :

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

   a. Elkay Manufacturing Co.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Oasis Corporation.

2. Description: ARI 1010, remote chiller equipment for installation separate from drinking fountains.


   1) Chassis: Galvanized or corrosion-resistant-coated steel.
   2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
   3) Controls: Adjustable thermostat.
   4) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.


2.4 FIXTURE SUPPORTS

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. Josam Co.
2. MIFAB Manufacturing, Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.

1. Type I: Hanger-type carrier with two vertical uprights.
2. Type II: Bilevel, hanger-type carrier with three vertical uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.

B. Set remote water coolers on support system, unless otherwise indicated.

C. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.

C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

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

3.4 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

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

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

3.5 FIELD QUALITY CONTROL

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

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION
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. Medical compressed-air piping, designated "medical air."
2. Healthcare laboratory compressed-air piping, designated "medical laboratory air."
3. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air."

B. Related Requirements:

1. Section 123570 "Healthcare Casework" for compressed-air outlets in healthcare casework.
2. Section 221513 "General-Service Compressed-Air Piping" for general-service compressed-air piping and specialties.
3. Section 226119 "Compressed-Air Equipment for Laboratory and Healthcare Facilities" for air compressors and specialties.
4. Section 226400 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.3 DEFINITIONS

A. Medical compressed-air piping systems include medical air, dental air, instrument air, and medical laboratory air.

B. Nonmedical compressed-air piping systems include laboratory air piping systems.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Certificates: For medical compressed-air manifolds, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Material Certificates: Signed by Installer certifying that medical compressed-air piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

D. Brazing certificates.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 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. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical compressed-air pressure outlets.
   a. Medical Air: Equal to 15 percent of amount installed, but no fewer than 2 units.
   b. Instrument Air: Equal to 15 percent of amount installed, but no fewer than 2 units.

   a. Medical Air D.I.S.S. No. 1160: Equal to 15 percent of amount installed, but no fewer than 2 units.
   b. Instrument Air D.I.S.S. No. 1160: Equal to 15 percent of amount installed, but no fewer than 2 units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:


2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

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

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical air operating at 50 to 55 psig.

B. Laboratory air operating at 50 psig.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Medical compressed-air manifolds shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the manifold will remain in place without separation of any parts when subjected to the seismic forces specified.

2. Component Importance Factor is 1.0.

2.3 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99 for medical air piping materials.

B. Comply with ASME B31.1, "Power Piping," for laboratory air piping operating at more than 150 psig.

C. Comply with ASME B31.9, "Building Services Piping," for laboratory air piping operating at 150 psig or less.

D. Copper Medical Gas Tube: ASTM B 819, Type K, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.

E. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.

F. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

G. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.


2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
H. Shape-Memory-Metal Couplings:

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. Aerofit, Inc.
   b. Smart Tap; Smart Technology, Inc.

2. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

I. Flexible Pipe Connectors:

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. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Metraflex Company (Thc).
   d. Universal Metal Hose.

2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 200 psig minimum.
   b. End Connections: Plain-end copper tube.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:
   a. Steel Box with Aluminum Cover:
      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) Amico Corporation.
b) Ohio Medical Corporation.

b. Steel Box with Stainless-Steel Cover:

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) BeaconMedaes.
b) Tri-Tech Medical.

c. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

1) Interior Finish: Factory-applied white enamel.
2) Cover Plate: Aluminum with frangible or removable windows.
3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

C. Ball Valves:

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

a. Amico Corporation.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. BeaconMedaes.
d. Ohio Medical Corporation.
e. Tri-Tech Medical.


3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever type with locking device.
8. Stem: Blowout proof with PTFE or TFE seal.

D. Check Valves:

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

a. Amico Corporation.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. Ohio Medical Corporation.
d. Tri-Tech Medical.

2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig minimum.

E. Safety Valves:
1. Bronze body.
2. ASME-construction, poppet, pressure-relief type.
3. Settings to match system requirements.

F. Pressure Regulators:
1. Bronze body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
4. Rated for 250-psig minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

2.6 MEDICAL COMPRESSED-AIR SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amico Corporation.
2. Ohio Medical Corporation.
3. Tri-Tech Medical.

B. General Requirements for Medical Compressed-Air Service Connections:
1. Suitable for specific medical air pressure and service listed.
2. Include roughing-in assemblies, finishing assemblies, and cover plates.
3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
4. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent air leakage.
4. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:
1. Brass housing with primary check valve.
2. Double seals that will prevent air leakage.
3. Cover plate with gas-service label.

E. Quick-Coupler Pressure Service Connections:
   1. Outlets for medical air with noninterchangeable keyed indexing to prevent interchange between services.
   2. Constructed to permit one-handed connection and removal of equipment.
   3. With positive-locking ring that retains equipment stem in valve during use.

F. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

G. Cover Plates:
   1. One piece.
   2. Aluminum
   3. Permanent, color-coded, identifying label matching corresponding service.

2.7 MEDICAL COMPRESSED-AIR PRESSURE CONTROL PANELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amico Corporation.
   2. BeaconMedaes.

B. Description:
   1. Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions.
   2. Manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
   3. Minimum Working Pressure: 80 psig
   5. Pressure Gages: 0 to 300 psig.
   7. Before final assembly, provide temporary dust shield and U-tube for testing.
   8. Label cover plate "Air Pressure Control."

2.8 MEDICAL COMPRESSED-AIR MANIFOLDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amico Corporation.
2. BeaconMedaes.
3. Ohio Medical Corporation.
4. Tri-Tech Medical.

B. Comply with NFPA 99, Chapter "Manifolds for Gas Cylinders without Reserve Supply."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Central Control-Panel Unit:
   1. Weatherproof cabinet.
   2. Supply and delivery pressure gages.
   3. Electrical alarm-system connections and transformer.
   4. Indicator lights or devices.
   5. Manifold connection.
   6. Pressure changeover switch.
   7. Line-pressure regulator.
   8. Shutoff valves.

E. Manifold and Headers:
   1. Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks.
   2. Designed for 2000-psig minimum inlet pressure.
   3. Cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1.
   4. Individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.

F. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.

G. Mounting Floor with support legs for manifold control cabinet.

H. Label manifold control unit with permanent label identifying compressed air and system operating pressure.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
   a. Scrub to ensure complete cleaning.
   b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

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

B. Comply with NFPA 99 for installation of compressed-air piping.

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

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

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

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

G. Install compressed-air piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

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

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

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

O. Install medical air piping to medical air service connections specified in this Section, to medical air service connections in equipment specified in Section 226313 "Gas Piping for Laboratory
and Healthcare Facilities," and to equipment specified in other Sections requiring medical air service.

P. Piping Restraint Installation: Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

Q. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

S. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on compressed-air piping where reduced pressure is required.

F. Install flexible pipe connectors in discharge piping[ and in inlet air piping from remote air-inlet filter] of each air compressor.

3.4 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Flanged Joints: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
E. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

3.5 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION

A. Install compressed-air pressure control panel in walls. Attach to substrate.

B. Install compressed-air manifolds on concrete base anchored to substrate.

C. Install compressed-air cylinders and connect to manifold piping.

D. Install compressed-air manifolds with seismic restraints as indicated.

E. Install compressed-air-cylinder wall storage racks attached to substrate.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

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

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

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

1. NPS 1/4: 60 inches with 3/8-inch rod.
2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
4. NPS 1: 96 inches with 3/8-inch rod.
6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.
9. NPS 3: 14 feet with 1/2-inch rod.
10. NPS 3-1/2: 15 feet with 1/2-inch rod.
11. NPS 4: 16 feet with 1/2-inch rod.
12. NPS 5: 18 feet with 1/2-inch rod.
14. NPS 8: 23 feet with 3/4-inch rod.

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

3.7 IDENTIFICATION

A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Air: Black letters on yellow background.
2. Medical Laboratory Air: Black letters on yellow-and-white checkerboard background.

3.8 FIELD QUALITY CONTROL FOR MEDICAL COMPRESSED-AIR PIPING IN HEALTHCARE FACILITIES

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical compressed-air piping in healthcare facilities and to prepare test and inspection reports.

B. Tests and Inspections:

1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical vacuum piping systems.

2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:

   a. Initial blowdown.
   b. Initial pressure test.
   c. Cross-connection test.
   d. Piping purge test.
   e. Standing pressure test for positive-pressure medical compressed-air piping.
   f. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

   a. Standing pressure test.
   b. Individual-pressurization cross-connection test.
   c. Valve test.
   d. Master and area alarm tests.
   e. Piping purge test.
   f. Piping particulate test.
   g. Piping purity test.
h. Final tie-in test.
i. Operational pressure test.
j. Medical air purity test.
k. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

a. Inspections performed.
b. Procedures, materials, and gases used.
c. Test methods used.
d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

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

A. Testing Agency: Engage qualified testing agency to perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and to prepare test and inspection reports.

B. Tests and Inspections:

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

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.10 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.11 PIPING SCHEDULE

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Flanges may be used where connection to flanged equipment is required.
C. Medical Air Piping except Instrument Air Piping Larger Than NPS 3 and Operating at More Than 185 psig: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

D. Instrument Air Piping Larger Than NPS 3 and Operating at More Than 185 psig: Type K, copper tube; wrought-copper fittings; and brazed joints.

E. Laboratory Air Piping except Laboratory Air Piping Larger Than NPS 3 and Operating at More Than 185 psig: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

F. Laboratory Air Piping Larger Than NPS 3 and Operating at More Than 185 psig: Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.12 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226113
SECTION 226119

COMPRESSED-AIR EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

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. Oil-free, reciprocating air compressors.
2. Oilless, reciprocating air compressors.
3. Liquid-ring air compressors.
4. Rotary-screw air compressors.
5. Scroll air compressors.
6. Compressed-air purification systems.
7. Compressed-air filter assemblies.
8. Dental air compressors.
9. Dental air-compressor control panels.

B. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for compressed-air equipment local alarms.

1.3 DEFINITIONS

A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.

B. Laboratory Air Equipment: Compressed-air equipment and accessories for nonmedical laboratory facilities.

C. Medical air equipment includes medical and healthcare laboratory air compressors and accessories for healthcare facilities.

D. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air compressors, compressed-air dryers, and compressed-air purification systems.
1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 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. Air-Compressor, Inlet-Air Filter Elements: Equal to 15 percent of quantity installed, but no fewer than 2 units.
2. Belts: One for each belt-driven compressor.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Laboratory Air Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.
2. Medical Air Equipment for Healthcare Facilities: Qualify installers according to ASSE 6010.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the compressed-air equipment testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.

2.2 GENERAL REQUIREMENTS FOR AIR COMPRESSORS

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.


C. Comply with UL 544, "Medical and Dental Equipment," for medical compressed-air equipment.

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

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
   1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
   3. Control Voltage: 120-V ac or less, using integral control power transformer.
   5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   6. Instrumentation: Include discharge-air and receiver pressure gages, air-filter maintenance indicator, hour meter, air-compressor discharge-air and coolant temperature gages, and control transformer.
   7. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
   2. Interior Finish: Corrosion-resistant coating.
   3. Accessories: Include safety valve, pressure gage, automatic drain, and pressure regulator.

2.3 RECIPROCATING AIR COMPRESSORS

A. Oil-Free, Reciprocating Air Compressors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
following:

a. Amico.
b. Ingersoll-Rand.
c. Quincy Compressor.
d. Tri-Tech Medical.

2. Description: Packaged unit.

3. Air Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber and lubricated crankcase, and of construction that prohibits oil from entering compression chamber.

   a. Submerged gear-type oil pump, and oil filter.
   b. Intercooler between stages of two-stage units.
   c. Combined high discharge-air temperature and low lubrication-oil pressure switch.
   d. Belt guard totally enclosing pulleys and belts.

4. Receiver and accessories.

B. Oilless, Reciprocating Air Compressors

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

   b. Quincy Compressor.
   c. Tri-Tech Medical.

2. Description: Packaged unit.

3. Air Compressor(s): two-stage, oilless (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.

   a. High discharge-air temperature switch.
   b. Belt guard totally enclosing pulleys and belts.
   c. Intercooler between stages of two-stage units.

4. Receiver and accessories.

5. Receiver:

   a. Orientation: Horizontal arrangement.
   b. Capacity: 80gal.
   c. Interior Finish: Epoxy or galvanized
   d. Pressure Rating: 125 psig minimum.
   e. Pressure Regulator Setting: 100psig.
   f. Pressure Relief Valve Setting: 125 psig.
   g. Drain: Automatic valve.
2.4 INLET-AIR FILTERS
A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
   1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.
B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
   1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   2. Capacity: Match total capacity of connected air compressors, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.5 COMPRESSED-AIR DRYERS
A. Desiccant Compressed-Air Dryers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BeaconMedaes.
      b. Donaldson Company, Inc.
      c. Parker Hannifin Corp.
   2. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 deg F, 100-psig air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

2.6 COMPRESSED-AIR PURIFICATION SYSTEMS
A. Compressed-Air Purification Systems:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Healthcare Products Inc.
      b. Donaldson Company, Inc.
      c. Ingersoll-Rand.
   2. Description: Compressed-air purification system sized for maximum connected equipment capacity with coalescing, particulate, and activated-charcoal filters; compressed-air dryer; catalytic converter; gages and thermometers; and controls.
   3. Include the following capabilities:
a. Removal of excessive moisture, solid particulates, oil and oil mist, carbon monoxide, and hydrocarbon vapors.
b. Automatic ejection of condensate from airstream.
c. Production of air complying with USP - NF for medical air.
d. Capacity and dew point indicated, but not higher than 35 deg F at 100 psig

4. Filters: Parallel duplex filters, each sized for maximum system demand, with valved bypass for filter servicing.
   a. Inlet Filters: 5 micrometers.
   b. Outlet Filters: 1 micrometer(s).

5. Accessories: Inlet and outlet pressure gages, thermometers, safety valves, and shutoff valves; and automatic ejection of condensate from airstream.

6. Differential Pressure Switch: Adjustable, diaphragm type, with electrical connections for alarm system, to indicate when air-pressure drop through filters rises to more than 2 psig greater than when new and clean.
   a. Inlet Connection: From inlet to particulate filter.
   b. Outlet Connection: To outlet from final activated-charcoal filter.

7. Compressed-Air Dryer: Twin-tower desiccant type with automatic controls, purge system, and mufflers

2.7 COMPRESSED-AIR FILTER ASSEMBLIES

A. Compressed-Air Filter Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Pneumatics, Inc.
   b. Donaldson Company, Inc.
   c. Ingersoll-Rand.
   d. SPX Air Treatment.
   e. Zeks Compressed Air Solutions.

2. Description: Filter assemblies suitable for compressed air, in parallel duplex arrangement. Size each assembly for maximum capacity of connected equipment and operating pressure of compressed-air system. Include automatic ejection of condensate from airstream, inlet and outlet pressure gages, and shutoff valves.
   a. Option: Factory-fabricated filter system consisting of three air filters equivalent to those specified, pipe, fittings, valves, differential pressure switch, and enclosure; and with additional automatic drain traps and gages.

3. Size filter assemblies for 5-psig maximum air-pressure drop when filters are new and clean, at system rated capacity, and at 100-psig pressure.

4. Differential Pressure Switch: Adjustable, diaphragm type, with electrical connections for alarm system, to indicate when air-pressure drop through filters rises to more than 2 psig greater than when new and clean.

5. Particulate Filters: Collection efficiency of 98 percent retention of particles 1 micrometer
7. Coalescing Filters: Collection efficiency of 99.9 percent retention of particles 0.3 micrometer and smaller.
8. Include automatic drain trap for each filter.

2.8 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: Open, dripproof.
2. Enclosure Materials: Cast iron.
4. NEMA Design: 1
5. Service Factor: 1.2
6. Electrical Characteristics:
   a. see drawings

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory air and medical air applications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.2 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation:

1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install the following devices on compressed-air equipment:
   a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
   b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
   c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
B. Nonmedical Laboratory Compressed-Air Equipment Installation:

1. Install compressed-air equipment, except wall-mounted equipment and diaphragm air compressors, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

4. Install diaphragm air compressors on floor counter insert location.
   a. Anchor air compressors to surface according to manufacturer's written instructions and seismic criteria applicable to Project.

C. Medical Compressed-Air Equipment Installation:

1. Install according to ASSE 6010 and NFPA 99.

2. Install compressed-air equipment, except wall-mounted equipment, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

3. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

4. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

D. Dental Air System Equipment Installation:

1. Install according to ASSE 6010 and NFPA 99.

2. Install dental air system units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

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

3.3 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for compressed-air piping specified in Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.
F. Connect water supply to compressed-air equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.4 IDENTIFICATION

A. Identify nonmedical laboratory compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL COMPRESSED-AIR EQUIPMENT

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. Medical Compressed-Air Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air equipment concurrently with tests, inspections, and certification of medical vacuum equipment medical vacuum piping medical compressed-air piping and medical gas piping systems.

2. Preparation: Perform medical compressed-air equipment tests according to requirements in NFPA 99 for the following:

   a. Air-quality purity test.
   b. System operation test.

3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical compressed-air equipment.

4. Replace damaged and malfunctioning controls and equipment.

5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

D. Components will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.
3.6 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check for lubricating oil in lubricated-type equipment.
   3. Check belt drives for proper tension.
   4. Verify that air-compressor inlet filters and piping are clear.
   5. Check for lubricating oil in lubricated-type equipment.
   6. Check for lubricating oil in lubricated-type equipment.
   7. Check that equipment is properly attached to substrate.
   8. Check for lubricating oil in lubricated-type equipment.
   9. Check for lubricating oil in lubricated-type equipment.
   10. Check for lubricating oil in lubricated-type equipment.

B. Prepare written report documenting testing procedures and results.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air compressors, compressed-air dryers, compressed-air purification units, and compressed-air filter assemblies.

END OF SECTION 226119
SECTION 226213

VACUUM PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

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. Medical-surgical vacuum piping, designated "medical vacuum."
      2. Healthcare laboratory vacuum piping, designated "medical laboratory vacuum."
   B. Related Requirements:
      1. Section 123570 "Healthcare Casework" for vacuum inlets in healthcare casework.
      2. Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities" for vacuum producers and accessories.

1.3 DEFINITIONS
   A. HVE: High-volume (oral) evacuation.
   B. Medical vacuum piping systems include medical vacuum, HVE, and medical laboratory vacuum piping systems.
   C. Nonmedical laboratory vacuum piping systems include laboratory low-vacuum and laboratory high-vacuum piping systems.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Sustainable Design Submittals:

1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For Installer and testing agency.
   B. Material Certificates: Signed by Installer certifying that medical vacuum piping materials comply with requirements in NFPA 99.
C. Brazing certificates.
D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.7 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. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical vacuum suction inlets.
   a. Medical Vacuum: Equal to 0 percent of amount installed, but no fewer than 0 units.
   b. WAGD: Equal to 0 percent of amount installed, but no fewer than 0 units.

   a. Medical Vacuum D.I.S.S. No. 1220: Equal to 0 percent of amount installed, but no fewer than 0 units.
   b. WAGD D.I.S.S. No. 2220: Equal to 0 percent of amount installed, but no fewer than 0 units.

1.8 QUALITY ASSURANCE
A. Installer Qualifications:
   2. Pressure-Seal Joining Procedure for Copper Tubing: An authorized representative who is trained and approved by manufacturer.
   3. Extruded-Tee Outlet Procedure: An authorized representative who is trained and approved by manufacturer.
   4. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

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

2.1 SYSTEM DESCRIPTION

A. Medical vacuum operating at 15 in. Hg.

B. Medical laboratory vacuum operating at 12 in. Hg.

2.2 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99 for medical vacuum piping materials.

B. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.

C. Copper Water Tube: ASTM B 88, Type M, seamless, drawn temper.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
   1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Shape-Memory-Metal Couplings:
   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. Aerofit, Inc.
      b. Smart Tap; Smart Technology, Inc.
   2. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

G. Pressure-Seal Fittings:
   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. Viega LLC.
   2. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
3. NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

   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. T-DRILL Industries Inc.

J. PVC Fittings: ASTM D 2466, Schedule 40; socket type.
K. Transition Fittings: PVC socket type with copper threaded insert on one end.
L. Flexible Pipe Connectors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex-Hose Co., Inc.
      b. Flexicraft Industries.
      c. Metraflex Company (The).
      d. Universal Metal Hose.
   2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
      a. Working-Pressure Rating: 200 psig minimum.
      b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS
A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
C. Threaded-Joint Tape: PTFE.
D. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.
   1. Double click to insert sustainable design text for adhesive primer.
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health’s "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
   3. Solvent cement shall have a VOC content of 510 g/L or less.
4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:
   a. Steel Box with Aluminum Cover:
      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) Allied Healthcare Products Inc.
         b) Amico Corporation.
         c) Ohio Medical Corporation.

   b. Steel Box with Stainless-Steel Cover:
      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) BeaconMedaes.
         b) Tri-Tech Medical.

   c. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.
      1) Interior Finish: Factory-applied white enamel.
      2) Cover Plate: Aluminum or stainless-steel with frangible or removable windows.
      3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

C. Copper-Alloy Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Amico Corporation.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. BeaconMedaes.
d. Ohio Medical Corporation.
e. Tri-Tech Medical.


3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever type with locking device.
8. Stem: Blowout proof with PTFE or TFE seal.

D. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amico Corporation.
   b. Apollo Flow Controls; Conbraco Industries, Inc.
   c. Ohio Medical Corporation.
   d. Tri-Tech Medical.

2. Description: In-line pattern, bronze.

3. Pressure Rating: 300 psig minimum.

E. PVC Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America.
   c. Georg Fischer Inc.
   d. Hayward Flow Control.
   e. Spears Manufacturing Company.


3. Description: With union ends and 150-psig 8psig minimum working-pressure rating and suitable for vacuum service.

F. PVC Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America.
   c. Georg Fischer Inc.
   d. Spears Manufacturing Company.
   e. Thermoplastic Valves, Inc.

2. Description: Lug type with lever handle and 150-psig 8 psig minimum working-pressure rating and suitable for vacuum service.

G. PVC Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America.
   c. Georg Fischer Inc.
   d. Spears Manufacturing Company.
   e. Thermoplastic Valves, Inc.

2. Description: Ball-, in-line-, piston-, or swing-check design with flanged or union ends and 70-psig 8 psig minimum working-pressure rating and suitable for vacuum service.

2.5 MEDICAL VACUUM SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amico Corporation.
   2. BeaconMedaes.
   3. Ohio Medical Corporation.
   4. Tri-Tech Medical.

B. General Requirements for Medical Vacuum Service Connections:
   1. Suitable for specific medical vacuum service listed.
   2. Include roughing-in assemblies, finishing assemblies, and cover plates.
   3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
   4. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:
   1. Steel outlet box for recessed mounting and concealed piping.
   2. Brass-body inlet block.
   3. Seals that will prevent vacuum leakage.
   4. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-
end dust cap.

D. Finishing Assembly:
   1. Brass housing with primary check valve.
   2. Seals that will prevent vacuum leakage.
   3. Cover plate with gas-service label.

E. Quick-Coupler Suction Service Connections:
   1. Inlets for medical vacuum and with noninterchangeable keyed indexing to prevent interchange between services.
   2. Constructed to permit one-handed connection and removal of equipment.
   3. With positive-locking ring that retains equipment stem in valve during use.

F. D.I.S.S. Suction Service Connections:
   1. Inlets complying with CGA V-5.
   2. Threaded indexing to prevent interchange between services.
   3. Constructed to permit one-handed connection and removal of equipment.

G. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.

H. Cover Plates:
   1. One piece.
   2. Aluminum
   3. Permanent, color-coded, identifying label matching corresponding service.

2.6 NITROGEN

A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
3.2 PIPING INSTALLATION

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

B. Comply with NFPA 99 for installation of vacuum piping.

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

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

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

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

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

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

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

O. Install medical vacuum piping from medical vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.

P. Piping Restraint Installation: Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
Q. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

S. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

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

U. Install unions in PVC vacuum piping NPS 2 and smaller adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

V. Install flanges in PVC vacuum piping NPS 2-1/2 and larger adjacent to flanged valves and at final connection to each machine, specialty, and piece of equipment.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.4 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

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

D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Do not use flux. Continuously purge joint with oil-free dry nitrogen
during brazing.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

G. PVC-to-Copper Joints: Join transition fitting PVC socket end as solvent-cemented joint to PVC pipe and join fitting end with insert to copper tube as threaded joint.

H. Extruded-Tee Outlets: Form branches in copper tube according to ASTM F 2014, with tools recommended by tube manufacturer.

I. Flanged Joints:
   1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
   2. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

J. Pressure-Sealed Joints: Join copper tube and copper and copper-alloy fittings with tools recommended by fitting manufacturer.

K. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

L. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. Apply primer and join according to ASME B31.9 and ASTM D 2672 for solvent-cemented joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

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

D. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.
G. Support horizontal piping within 12 inches of each fitting and coupling.

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

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.
   8. NPS 2-1/2: 13 feet with 1/2-inch rod.
   9. NPS 3: 14 feet with 1/2-inch rod.
   10. NPS 3-1/2: 15 feet with 1/2-inch rod.
   11. NPS 4: 16 feet with 1/2-inch rod.
   12. NPS 5: 18 feet with 1/2-inch rod.
   14. NPS 8: 23 feet with 3/4-inch rod.

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

K. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and Smaller: 30 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 36 inches with 3/8-inch rod.
   3. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
   4. NPS 4 and NPS 5: 48 inches with 1/2-inch rod.
   5. NPS 6 and NPS 8: 54 inches with 5/8-inch rod.

L. Install supports for vertical PVC piping every 48 inches.

3.6 IDENTIFICATION

A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical vacuum piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   1. Medical Vacuum: Black letters on white background.
   2. Medical Laboratory Vacuum: Black boxed letters on white-and-black checkerboard background.

3.7 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL VACUUM PIPING

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections of medical vacuum piping systems in healthcare facilities and to prepare test and
inspection reports.

B. Tests and Inspections:

1. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of medical compressed-air piping systems.

2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
   a. Initial blowdown.
   b. Initial pressure test.
   c. Cross-connection test.
   d. Piping purge test.
   e. Standing pressure test for vacuum systems.
   f. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
   a. Standing pressure test.
   b. Individual-pressurization cross-connection test.
   c. Valve test.
   d. Master and area alarm tests.
   e. Piping purge test.
   f. Final tie-in test.
   g. Operational vacuum test.
   h. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.8 FIELD QUALITY CONTROL FOR LABORATORY FACILITY NONMEDICAL VACUUM PIPING

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of vacuum piping in nonmedical laboratory facilities and to prepare test and inspection reports.

B. Tests and Inspections:

1. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   a. Test Pressure for Copper Tubing: 100 psig.
b. Test Pressure for PVC Piping: 100 psig.

2. Repair leaks and retest until no leaks exist.
3. Inspect filters for proper operation.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.9 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 PIPING SCHEDULE

A. Connect new copper tubing to existing copper tubing with memory-metal couplings.

B. Connect PVC pipe to copper tube with transition fittings.

C. Flanges may be used where connection to flanged equipment is required.

D. Medical Vacuum Piping: Use copper water tube, wrought-copper fittings, and brazed joints.

E. HVE Piping: Use one of the following piping materials for each size range:

   1. NPS 4 and Smaller: Copper water tube, wrought-copper fittings, and soldered joints.
   2. NPS 4 and Smaller: Copper water tube, press-type fittings, and pressure-sealed joints.
   3. NPS 4 and Smaller: Schedule 40 PVC pipe, Schedule 40 PVC fittings, and solvent-cemented joints.

F. Medical Laboratory Vacuum Piping: Use one of the following piping materials for each size range:

   1. NPS 4 and Smaller: Copper water tube, wrought-copper fittings, and brazed joints.
   2. NPS 4 and Smaller: Copper water tube, press-type fittings, and pressure-sealed joints.

G. Laboratory Low-Vacuum Piping: Use one of the following piping materials for each size range:

   1. NPS 4 and Smaller: Copper water tube, wrought-copper fittings, and soldered joints.
   2. NPS 4 and Smaller: Copper water tube, press-type fittings, and pressure-sealed joints.
   3. All Sizes: Extruded-tee fittings and brazed joints may be used instead of standard tee fittings.
3.11 VALVE SCHEDULE

A. Shutoff Valves:
   1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.
   2. PVC Piping:
      a. NPS 4 and Smaller: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions PVC ball valve.

B. Zone Valves: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226213
SECTION 226219

VACUUM EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

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. Reciprocating vacuum pumps.
2. Liquid-ring vacuum pumps.
3. Oil-sealed, rotary-screw vacuum pumps.
4. Rotary, dry-claw vacuum pumps.
5. Rotary, sliding-vane vacuum pumps.
6. Turbine exhausters.
7. Diaphragm vacuum pumps.
8. Dental vacuum pumps.
9. Dental vacuum pump control panels.

B. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for vacuum equipment local alarms.

1.3 DEFINITIONS

A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in acfm.
B. HVE: High-volume oral evacuation for dental applications in healthcare facilities.
C. Laboratory Vacuum Equipment: Vacuum producers and accessories for nonmedical laboratory facilities.
D. Medical Vacuum Equipment: Includes medical and healthcare laboratory vacuum producers and accessories for healthcare facilities.
E. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For vacuum producers.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For Installer and testing agency.
B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.7 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. Belts: One for each belt-driven vacuum producer.

1.8 QUALITY ASSURANCE
A. Installer Qualifications:
   1. Laboratory Vacuum Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vacuum equipment mounting.

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

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

B. Comply with NFPA 99, "Health Care Facilities," for vacuum equipment and accessories for medical vacuum systems.

C. Comply with UL 544, "Medical and Dental Equipment," for medical vacuum equipment.

D. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

   1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
   3. Control Voltage: 120-V ac or less, using integral control power transformer.
   5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   6. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
   7. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.

   1. Interior Finish: Corrosion-resistant coating.
   2. Accessories: Include vacuum relief valve, vacuum gage, and drain.

2.3 RECIPROCATING VACUUM PUMPS

A. Reciprocating Vacuum Pumps:

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

      a. Allied Healthcare Products Inc.
      b. Amico.
      c. Ingersoll-Rand.
2. Description: Packaged unit.

3. Vacuum Pump(s): Lubricated, reciprocating-piston type.
   a. Inlet filters.
   b. Low-lubrication oil pressure switches, submerged gear-type oil pumps, and oil filters.
   c. Belt guards totally enclosing pulleys and belts.

5. Outlet silencers and oil-mist separators on discharge piping.

B. Capacities and Characteristics:
   a. See drawings.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: Open, dripproof.
2. Enclosure Materials: Cast iron or Rolled steel.
3. Motor Bearings: 200,000hr
4. Unusual Service Conditions:
   a. Ambient Temperature: 95deg F.
   b. Altitude: above sea level.
   c. High humidity.

5. Efficiency: Premium efficient.
6. NEMA Design: 1.
7. Service Factor: 1.20.
8. Electrical Characteristics:
   a. See drawings.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory vacuum and medical vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

A. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.

B. Equipment Mounting:

Trinity Valley Community College
Health Science Center
RSA Project No. 1707.00

VACUUM EQUIPMENT FOR LABORATORY
AND HEALTHCARE FACILITIES
50% CD’S / GMP Pricing

21 00 00 - 4
December 29, 2017
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"

2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Install vacuum equipment anchored to substrate.

D. Orient equipment so controls and devices are accessible for servicing.

E. Maintain manufacturer’s recommended clearances for service and maintenance.

F. Install the following devices on vacuum equipment:

   1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.

   2. Drain Valves: Install on receivers and separators. Discharge receiver condensate over nearest floor drain. Discharge separator oral evacuation fluids by direct connection into sanitary waste piping system.

3.3 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.

F. Connect water supply to vacuum equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.4 IDENTIFICATION

A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.
3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL VACUUM EQUIPMENT

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. Medical Vacuum Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum equipment concurrently with tests, inspections, and certification of medical compressed-air equipment medical compressed-air piping medical vacuum piping and medical gas piping systems.

2. Preparation: Perform medical vacuum equipment tests according to requirements in NFPA 99 for the following:

   a. System operation test.

3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical vacuum equipment.

4. Replace damaged and malfunctioning controls and equipment.

5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

   a. Inspections performed.
   b. Procedures and materials used.
   c. Test methods used.
   d. Results of tests.

D. Components will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer’s written instructions.

2. Check for lubricating oil in lubricated-type equipment.

3. Check belt drives for proper tension.

4. Verify that vacuum producer outlet piping is clear.

5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.

6. Check safety valves for correct settings.

7. Check for proper seismic restraints.

8. Drain receiver and separator tank(s).

9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

10. Test and adjust controls and safeties.

B. Verify that vacuum equipment is installed and connected according to the Contract Documents.
C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.

D. Prepare written report documenting testing procedures and results.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain vacuum producers.

END OF SECTION 226219
SECTION 23 00 00
DIVISION 23 SUBMITTAL PROCEDURES

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Related Requirements:
1. Division 01 Section "Submittal Procedures" for coordinating Division 23 submittals with other Divisions.
2. Division 01 Section "Operation and Maintenance Data" for submitting operation and maintenance manuals.
3. Division 01 Section "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
4. Division 01 Section "Demonstration and Training" for training of Owner's personnel.

1.3 DEFINITIONS
A. Action Submittals: Written and graphic information and physical samples that require Engineer's and Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Engineer's and Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

C. File Transfer Protocol (FTP): Communications protocol that enables transfer of files to and from another computer over a network and that serves as the basis for standard Internet protocols. An FTP site is a portion of a network located outside of network firewalls within which internal and external users are able to access files.


1.4 ACTION SUBMITTALS
A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and Architect and additional time for handling and reviewing submittals required by those corrections.
1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.

1.5 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Engineer's Digital Data Files: Electronic digital data files of the Revit model used to produce the Contract Drawings will be provided by Engineer for Contractor's use in preparing submittals only after Engineer’s Release Form has been appropriately executed.

1. Engineer will furnish Contractor one set of digital data files used to produce the Contract Drawings for use in preparing Shop Drawings and Project record drawings.

a. Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to the Contract Drawings.


c. Contractor shall execute a data licensing agreement (Engineer’s Release Form) in substantial agreement with AIA Document C106, Digital Data Licensing Agreement.

d. The Contractor agrees as a pre-condition of the use of Engineer’s digital data files to provide Engineer with Contractor’s final files (Record Drawings) at the completion of the project in the same software version as provided by Engineer.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

2. Submit all submittal items required for Division 23 Sections concurrently unless partial submittals are indicated on approved submittal schedule. Product data submittals and shop drawings may be submitted in separate volumes.

3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.

4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. Engineer and Architect reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

5. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer and Architect will advise Contractor when a submittal being processed must be delayed for coordination.

6. Resubmittal Review: One resubmittal is allowed. Additional resubmittal reviews will be performed after Engineer’s review fees have been negotiated. Allow 15 days for review of each resubmittal.

C. Paper Submittals: Paper submittals will not be allowed.

D. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
   
   a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-231000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-231000.01.A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer and Architect.

4. Transmittal Form for Electronic Submittals: Use electronic form acceptable to Owner and Architect, containing the following information:
   
   a. Project name.
   b. Date.
   c. Name and address of Engineer.
   d. Name of Architect.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Names of subcontractor, manufacturer, and supplier.
   h. Category and type of submittal.
   i. Submittal purpose and description.
   j. Specification Section number and title.
   k. Specification paragraph number or drawing designation and generic name for each of multiple items.
   l. Drawing number and detail references, as appropriate.
   m. Location(s) where product is to be installed, as appropriate.
   n. Related physical samples submitted directly.
   o. Indication of full or partial submittal.
   p. Transmittal number, numbered consecutively.
   q. Submittal and transmittal distribution record.
   r. Other necessary identification.
   s. Remarks.

5. Metadata: Include the following information as keywords in the electronic submittal file metadata:
   
   a. Project name.
   b. Number and title of appropriate Specification Section.
   c. Manufacturer name.
   d. Product name.

E. Options: Identify options requiring selection by Engineer.

F. Deviations and Additional Information: Prepare on Contractor's letterhead, relevant information, requests for data, revisions other than those requested by Engineer on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

G. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's and Architect's action stamp.
PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by Division 23 Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Submit electronic submittals via email or directly to Project Web site as PDF electronic files.

2. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.
   a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.

B. Product Data:

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:
   a. Manufacturer's catalog cuts.
   b. Manufacturer's product specifications.
   c. Standard color charts.
   d. Statement of compliance with specified referenced standards.
   e. Testing by recognized testing agency.
   f. Application of testing agency labels and seals.
   g. Notation of coordination requirements.
   h. Availability and delivery time information.
4. For equipment, include the following in addition to the above, as applicable:
   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
   d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
   a. Identification of products.
   b. Schedules.
   c. Compliance with specified standards.
   d. Notation of coordination requirements.
e. Notation of dimensions established by field measurement.
f. Relationship and attachment to adjoining construction clearly indicated.
g. Seal and signature of professional engineer if specified.

2. BIM (Revit) File Incorporation: Develop and incorporate Shop Drawing files into Building Information Model established for Project.

D. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
2. Manufacturer and product name, and model number if applicable.
3. Number and name of room or space.
4. Location within room or space.

E. Coordination Drawing Submittals: Comply with requirements specified in Division 01 Section "Project Management and Coordination."

F. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Closeout Procedures."

G. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."

H. LEED Submittals: Comply with requirements specified in Division 01 sustainable design requirements Section.

I. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.

J. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

K. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

L. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

M. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

N. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

O. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.
P. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

Q. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:

1. Name of evaluation organization.
2. Date of evaluation.
3. Time period when report is in effect.
4. Product and manufacturers’ names.
5. Description of product.
6. Test procedures and results.
7. Limitations of use.

R. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency’s standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

S. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency’s standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

T. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer and Architect.

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01 Section “Closeout Procedures.”

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor’s approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ENGINEER’S ACTION

A. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or revisions required, and return it. Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action, as follows:

1. Engineer’s Review
a. No Exceptions Taken: Engineer’s review found no apparent discrepancies between submittal data and requirements of Contract Documents. No further submittal review action required from Contractor.
b. Accepted as Noted: Engineer’s review found the submittal to be in substantial conformance with the requirements of Contract Documents.
c. Rejected: Engineer’s review found the submittal to be in non-conformance with the requirements of Contract Documents.

2. Responses required by Contractor:
   a. Confirm: Contractor will review Engineer’s notations on submittal and confirm via written response the information requested by Engineer
   b. Revise: Contractor will review Engineer’s notations on submittal and revise submittal to comply.
   c. Resubmit: Contractor will make changes to submittal in accordance with Engineer’s notations and resubmit.

B. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Engineer and Architect.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may be returned by the Engineer without action.

END OF SECTION
SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

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

1.3 COORDINATION
A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS
A. Description: NEMA MG 1, Design B, medium induction motor.
B. Efficiency: Energy efficient, as defined in NEMA MG 1.
C. Service Factor: 1.15.
D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   5. Provide bearing protection ring for reduction of VFD/AC drive induced bearing damage.

2.5 SINGLE-PHASE MOTORS

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

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.
E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION
SECTION 23 05 14

VARIABLE-FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. BAS: Building automation system.
B. CPT: Control power transformer.
C. EMI: Electromagnetic interference.
D. IGBT: Insulated-gate bipolar transistor.
E. LAN: Local area network.
F. LED: Light-emitting diode.
G. MCP: Motor-circuit protector.
H. NC: Normally closed.
I. NO: Normally open.
J. OCPD: Overcurrent protective device.
K. PWM: Pulse-width modulated.
L. VFD: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of enclosed unit.
f. Features, characteristics, ratings, and factory settings of each VFD and installed devices.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Certificates: For each VFD, from manufacturer.

C. Harmonic Analysis Study and Report: Comply with IEEE 519 harmonic analysis for specific job site including total harmonic voltage distortion and total harmonic current distortion (TDD). The VFD manufacturer shall provide calculations specific to this installation showing total harmonic distortion less than 5%. Input filters shall sized and provided as required to ensure compliance with IEEE 519.

D. Source quality-control reports.

E. Field quality-control reports.

F. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
3. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.
   2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
   3. Humidity: Less than 95 percent (noncondensing).
   4. Altitude: Not exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items.

1.11 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
   1. Torque, speed, and horsepower requirements of the load.
   2. Ratings and characteristics of supply circuit and required control sequence.
   3. Ambient and environmental conditions of installation location.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. ABB.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.
5. Toshiba International Corporation.
6. Yaskawa Electric America, Inc; Drives Division.
7. Danfoss.

B. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: variable torque.

D. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F.
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F.
10. Altitude Rating: Not exceeding 3300 feet.
12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.3 times the base load current for two seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 5 percent.
15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.

Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.


Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 1800 seconds.
4. Deceleration: 0.1 to 1800 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
4. Inverter overcurrent trips.
5. VFD and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
10. Short-circuit protection.
11. Motor overtemperature fault.

Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

Integral Input Disconnecting Means and OCPD: NEMA KS 1, nonfusible switch, with power fuse block and Class T current-limiting fuses with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
2. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. NO alarm contact that operates only when circuit breaker has tripped.

2.2 CONTROLS AND INDICATION

A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

B. Historical Logging Information and Displays:

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

C. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

   1. Output frequency (Hz).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (V dc).
   9. Set point frequency (Hz).
   10. Motor output voltage (V ac).

D. Control Signal Interfaces:

   1. Electric Input Signal Interface:
      a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
      b. A minimum of six multifunction programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
      a. 0- to 10-V dc.
      b. 4- to 20-mA dc.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
   3. Output Signal Interface: A minimum of 2 programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:
      a. Output frequency (Hz).
b. Output voltage.
c. Output current (load).
d. DC-link voltage (Vdc).
e. Motor torque (percent).
f. Motor speed (rpm).
g. Motor power (kW).
h. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of 3 programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

E. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFD status and alarms and energy usage. Allows VFD to be used with an external system within a multi-drop LAN configuration; settings retained within VFD's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.
2. Embedded BAS Protocols for Network Communications: Modbus; protocols accessible via the communications ports.

2.3 LINE CONDITIONING AND FILTERING

A. Input Filtering: Provide input filters to minimize harmonics and distortion of waveform.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.4 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

2. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: Reduced-voltage (autotransformer) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFD while the motor is running in the bypass mode.
   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

   a. Solid-State Overload Relays:
      1) Switch or dial selectable for motor-running overload protection.
      2) Sensors in each phase.
      3) Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
   b. External overload reset push button.

2.5 OPTIONAL FEATURES

A. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

B. Remote digital operator kit.

C. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.
2.6 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Other Wet or Damp Indoor Locations: Type 4.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.7 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

   b. Pilot Lights: LED types; push to test.
   c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.


C. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grills; 120-V ac; obtained from integral CPT.

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to a motor that is comparable to that for which the VFD is rated.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.
PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HARMONIC ANALYSIS STUDY

A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFD input filtering to limit TDD and THD(V) at each VFD to specified levels.

B. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance Testing Specification.

3.3 INSTALLATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFD.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.
3.4 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Division 23 Section "Identification for HVAC Piping and Equipment."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 3 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFDs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
3.7 STARTUP SERVICE
A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING
A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

C. Set the taps on reduced-voltage autotransformer controllers.

D. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

E. Set field-adjustable pressure switches.

3.9 PROTECTION
A. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION
SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.

B. Related Sections:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   3. Division 23 Section "Vibration Controls for HVAC Piping and Equipment" for vibration isolation devices.
   4. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Pipe stands.
   4. Equipment supports.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural Steel 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.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with inturmed lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psi minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psi...
Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.6 PIPE STANDS

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

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

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

E. High-Type, Multiple-Pipe Stand:
   1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   2. Bases: One or more; plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

   1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

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

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

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

   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-
beams for heavy loads, with link extensions.

11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
   3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
   6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
   7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
   8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not
specified in piping system Sections.

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

END OF SECTION
SECTION 23 05 48

VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this section. If any requirements of this section and the requirements of other sections are in conflict, the requirements of this section shall prevail. Prior to proceeding, contact Engineer for clarification.

1.2 WORK INCLUDED

A. Provide complete noise control systems as shown or specified and in accordance with the requirements of the Contract Documents. System shall be complete with:

1. Foundations, vibration isolation, and supports for rigidly supported equipment.
2. Vibration Isolation
3. Fan and Duct System Plenums
4. Sealing Around Penetrations Through Walls and Slabs

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Consult all other Sections to determine the extent of work specified elsewhere but related to this Section. This work shall be properly coordinated to produce an installation satisfactory to the Owner. This work includes, but is not limited to the following:

1. Fans
2. Ductwork
3. Duct Insulation (External)
4. Duct Insulation (Internal Acoustical)
6. Piping
8. Heating and Cooling Equipment
11. Sealant

1.4 CONTRACTOR’S RESPONSIBILITY

A. The Contractor shall be responsible for verifying the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this specification. Any additional equipment needed to meet the intent of this specification, even if not specifically mentioned herein or in the Contract Documents, shall be supplied by the Contractor without claim for additional payment.

B. Performance or waiving of inspection, testing or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly with the Contract Documents. The Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architects to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.
1.5 MANUFACTURER’S RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:

1. Determine vibration isolation for all equipment and systems in accordance with all codes having jurisdiction on this project.
2. Provide piping and equipment isolation systems as scheduled or specified.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. The vibration isolation systems shall be guaranteed to have deflection indicated on the schedule on the drawings. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer’s instructions.
6. The vibration isolator vendor shall ensure that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators. Where additional support structure is required, this shall be provided by vibration isolator vendor.

1.6 BID PROPOSALS

A. The Contractor shall submit at the time of bidding the names and qualifications of the noise and vibration control supplier(s). If a supplier is not one of the pre-approved vendors, then the submittal shall be accompanied by a complete catalog of that supplier’s products and samples of each proposed vibration isolator.

B. Contractor shall submit at the time of bidding the design sound power level of each air moving device (including fans and package air handlers) as described in the Contract Documents. If the actual sound power generated by any device exceeds in any octave band the specified sound power levels for the equipment specified in the Contract Documents, the contractor shall include in his price system modifications as required to compensate for the additional noise at no expense to the Owner. Any such system modification shall be subject to review and approval.

1.7 SUBMITTALS

A. Contractor shall submit fully coordinated shop drawings for all vibration and noise control equipment. These submittals shall state the acoustical performance of the products as described below.

B. Sheet Metal: Coordinated shop drawings at 1/4” = 1’-0” minimum scale shall be submitted for review and approval to indicate the following:

1. Length, width, height, and elevation of bottom of each duct segment.
2. Sheet metal gauge
3. Location of duct silencers, fire dampers, and balancing dampers.
4. Transition segments marked with entrance and exit sizes, as well as length and elevation. Markings should indicate which sides are held level, and which ones slope.
5. If a duct segment is offset in the horizontal or vertical direction, this information must be noted.
6. Duct lining thickness.
7. Any restraints or points of conflict due to existing conditions or planned piping, conduit, structure, or finish which will interfere with the installation of the ductwork.
C. **Vibration Isolators**: Submittal to the Architect shall include drawings prepared by the isolation materials manufacturer showing the construction of the isolation devices to be used, including specific selection of isolators for the equipment to be furnished for this project.

1. Submittal of vibration isolation system schedule indicating the following:

   a) Manufacturer, type, model number, size
   b) Height when uncompressed and static deflection of each isolation element
   c) Spring constant of each isolation element
   d) Estimated imposed load on each isolation element
   e) Spring o.d., free operating, and solid heights
   f) Design of supplementary bases.
   g) Layout of isolator hangers, mounts, and other elements shown on an outline of the isolated equipment, including complete details of attachment to load-bearing structure or supplementary framing.
   h) Piping isolators shown and identified on piping layout drawings.

D. **Grilles and diffusers, variable air volume boxes, fan powered boxes**: Submit shop drawings complete with sound power levels generated by each terminal device at the air flow and pressure drop specified in the contract documents.

### 1.8 NOISE CRITICAL SPACES

A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces; noise levels due to equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall permit attaining sound pressure levels in all 8 octave bands in occupied spaces conforming to RC levels per ASHRAE handbook as indicated.

<table>
<thead>
<tr>
<th>Space</th>
<th>RC Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>30</td>
</tr>
<tr>
<td>Offices, counseling areas, and similar spaces</td>
<td>35</td>
</tr>
<tr>
<td>Public areas of the facility such as lobbies</td>
<td>Not to exceed 40</td>
</tr>
</tbody>
</table>

B. Penetrations by ducts, pipes and conduit between noise critical spaces shall be sleeved, packed and sealed airtight with non-hardening sealant as described herein.

### 1.9 DESCRIPTION OF SYSTEMS

A. **VIBRATION ISOLATION**

1. Building structure can provide a direct path for mechanically induced vibration to travel from mechanical equipment to noise critical spaces. Rotating or vibrating equipment such as fans, pumps, pipes and ducts shall be mounted on or suspended from vibration isolators to attenuate the vibration transfer from equipment into the building structure.
B. FAN NOISE ATTENUATION

1. Rotating fan blades generate noise which propagates along duct routes into noise critical spaces. To attenuate this noise, one or a combination of the following methods is employed:
   a) Internal Lining - Duct systems are internally lined as indicated herein.
   b) Foam Rod - Foam Rod is used to seal around duct penetrations as they pass through block work or concrete.
   c) Non-Hardening Sealant - Non-Hardening Sealant is used to seal the Foam Rod to the ducts and to the construction through which the ducts penetrate.
   d) Acoustical Plenums - Acoustical plenums include all plenums forming part of noise critical systems (fan plenums and duct system plenums). Acoustical plenums are constructed from sheet metal panels. The plenums are lined with glass fiber insulation to absorb sound.

C. SEALING OF PENETRATIONS

1. Building structures to isolate air-borne noise have been designed to surround all critical spaces and noisy spaces. The effectiveness of sound isolating structures can be severely compromised by penetrations for duct work and piping. Proper sealing and/or lagging (enclosure) around mechanical services penetrating these structures will maintain the integrity of the isolating structure.

1.10 QUALITY ASSURANCE

A. It is the objective of this Specification to provide for the control of noise and vibration due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

B. The installation of all noise and vibration control systems shall be under the supervision of the manufacturer's representative.

C. All vibration isolation equipment and materials shall be provided by a single manufacturer. The following manufacturers are approved provided systems are in compliance with the specified design and performance requirements:

2. Amber Booth, Houston, Texas
3. VMC East, Bloomingdale, New Jersey
4. Kinetics Noise Control, Dublin, Ohio

D. The following duct liner manufacturers are approved, provided the product is in compliance with the specified design and performance requirements:

1. Certainteed
2. Owens-Corning
3. Knauf

PART 2 - PRODUCTS

2.1 GENERAL
2.2 INTERNAL ACOUSTICAL DUCT AND PLENUM LINING

A. Duct liner shall comply with the requirement of NFPA 90A and the “Duct Liner Materials Standard” of the Thermal Insulation Manufacturer’s Association.

B. Sizes shown on the drawings are free area dimensions (after installation of duct liner).

C. All acoustical duct lining shall incorporate means to prevent fiber entrainment in the air stream.

D. Duct lining shall have minimum density of 1.5 pcf unless otherwise noted. All plenum lining insulations shall have a minimum density of 3 pcf unless otherwise noted.

2.3 FOAM ROD

A. Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

2.4 NON-HARDENING SEALANT

A. Sealant for penetrations shall be non-hardening polysulphide type.

B. Permanently flexible, approved firestop systems as specified in Section 07840 may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

2.5 PACKING MATERIAL FOR PENETRATIONS

A. Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 pcf.

2.6 FIRE DAMPERS

A. Fire dampers for noise critical duct systems shall be a type with the blade stored out of the air stream.

2.7 FLEXIBLE DUCT CONNECTORS

A. Flexible sleeves for duct connections shall be fabricated from flexible, airtight, coated fabric. Each sleeve shall be installed with at least 3 inches slack across a clear metal-to-metal gap of at least 4 inches (minimum of 7 inches of this fabric is required for each sleeve).

2.8 VIBRATION ISOLATION SYSTEMS

A. GENERAL

1. The static deflection of isolators shall be as given in the equipment schedule and specified below. The isolator schedule shall take precedence.

2. Vibration isolator sizes and layout shall be determined by the vibration isolator supplier.

3. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, verified, thus determining that the load is within the
proper range of the device and that the correct degree of vibration isolation is being provided according to the design.

4. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.

5. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10%.

6. All neoprene mountings shall have a Shore hardness of 30 to 60 ±5, or as specified herein, after minimum aging of 20 days or corresponding over-aging.

7. Housed or caged spring isolators are not acceptable.

8. Where steel spring isolation systems are described in the specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.

9. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

B. ISOLATOR TYPE DDNH

1. Type DDNH (Double Deflection Neoprene Hangers) shall consist of a molded neoprene isolating element in a steel hanger box. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 3/4 inch larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30 degree arc. When installed, the hanger box shall be allowed to rotate through a full 360 degrees without encountering any obstructions.

2. The isolator shall be manufactured with bridge bearing quality neoprene, and selected for a maximum durometer of 50 and designed for 15% strain. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3 inches.

(Type DDNH: Mason Industries Type HD)

C. ISOLATOR TYPE DDNM

1. Type DDNM (Double Deflection Neoprene Mounts) shall be laterally stable, double deflecting, molded neoprene isolators. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed and bolt holes shall be provided in the base. The mounts shall have leveling bolts rigidly secured to the equipment.

2. The isolator shall be manufactured with bridge bearing quality neoprene, and selected for a maximum durometer of 50 and designed for 15 percent strain. DDNM mounts shall be selected for a static deflection of 3/8 inch unless otherwise specified.

(Type DDNM: Mason Industries Type ND)

D. ISOLATOR TYPE NIS

1. Type NIS isolators shall be designed with a neoprene element to provide isolation in tension, shear or compression. Neoprene to bridge bearing quality with a maximum durometer of 50.
E. ISOLATOR TYPE SPNH

1. Type SPNH (Spring and Neoprene Hangers) shall consist of a steel spring in series with a neoprene isolating element. The spring shall have a minimum additional travel to solid equal to 50% of the specified deflection. The neoprene element shall have a static deflection of not less than 0.3 inches with a strain not exceeding 15%.

2. Unless otherwise specified, the static deflection of SPNH hangers shall be 2 inches.

3. Spring diameter and hanger box hole size shall be large enough to permit the hanger rod to swing through a 30 degree arc. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 3/4 inch larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked, and the hanger box shall be allowed to rotate through a full 360 degree arc without encountering any obstructions.

F. ISOLATOR TYPE SPNM

1. Type SPNM (Spring and Neoprene Mounts) shall have a free-standing and laterally stable steel spring without any housing. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall be not less than 80% of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50% of the specified static deflection.

2. Unless otherwise specified, the minimum static deflection of SPNM isolators for equipment mounted on grade slabs shall be 1 inch, and the minimum static deflection for equipment mounted above grade level shall be 2 inches.

3. Two Type WP isolation pads sandwiching a 16 gauge stainless or galvanized steel separator plate shall be bonded to the isolator baseplate.

4. Unless otherwise specified, isolators need not be bolted to the floor for indoor installations. If the base plates are bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

G. BASE TYPE CB

1. Inertia base Type CB (Concrete Base) shall have an integral rectangular structural steel form into which concrete is poured.

2. Perimeter members shall be beams of depth equal to 10% of the longest span of the base, but not more than 12 inches nor less than 6 inches deep. Forms shall include motor slide base and all reinforcing steel. Where anchor bolt locations fall in concrete, the reinforcing steel shall include drilled members with sleeves welded below the steel to accept the anchor bolts. Height saving steel brackets shall be used in all mounting locations.

3. When the concrete base is "T" shaped, isolators shall be located under the projections as well as under the main body in order to prevent cantilever distortion.

4. The structural perimeter frame, mounting templates, height saving brackets, and spring system shall be provided as an assembly by the vibration control vendor.
H. BASE TYPE CMB

1. Base Type CMB (Curb Mounted Base) for roof-mounted equipment shall be a structural steel base mounted directly to the structure with an upper floating section on adjustable steel springs. The upper frame shall provide continuous support for the equipment. Steel springs shall rest on 1/4" min. thickness neoprene pads and shall have a minimum static deflection of 2" unless otherwise specified. All-directional snubber bushings shall be 1/4" minimum thickness neoprene. All hardware shall be cadmium or zinc electroplated to provide a rust resistant finish.

2. Weather proofing shall consist of a continuous galvanized flexible counterflashing nailed over the lower curb’s waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers to allow for adjustment or replacement of springs. Lower curbs shall have provision for 2" insulation.

3. Duct connections shall be made using a length of flexible duct dimensioned to match the equipment opening, using a foam rubber gasket to seal against the unit bottom.

I. NEOPRENE MOUNTING SLEEVES

1. Neoprene mounting sleeves for hold-down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.

J. PIPE FLEXIBLE CONNECTORS

1. Flexible connectors for pipes shall be neoprene Mason Type MFNEC, MFTNC or as approved. Do not use control rods.

2.9 AIR HANDLING UNITS

A. Units shall be tested by an independent acoustical testing laboratory having NVLAP certification in accordance with AMCA Standard 300-08. The test setup shall be determined to most closely approximate the actual configuration of scheduled equipment.

2.10 FAN COIL UNITS

A. Unit manufacturer shall furnish when requested certified sound power levels for both discharged (ducted) air and casing radiated sound in each of the second through sixth octave bands for every unit furnished with inlet pressures of 0.75 inches, 1.5 inches, and 3 inches w.g. determined in accordance with ASHRAE Standard 36-72, latest publication. Unit discharge and radiated sound levels shall not cause occupied space sound pressure levels to exceed background noise levels for “noise critical spaces” as specified above.

PART 3 - EXECUTION

3.1 GENERAL

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All floor-mounted equipment shall be erected on 4" thick concrete housekeeping pads over the complete floor area of the equipment, unless otherwise specified. These pads shall be
integrally keyed to structural slab. Wherever vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted on concrete housekeeping pads unless otherwise specified to the contrary herein.

C. Furnish and install neoprene mounting sleeves for hold-down bolts to prevent any metal to metal contact.

D. All equipment shall be provided with lateral restraining isolators as required to limit horizontal motion to 1/4" maximum, under all operating conditions. Lateral restraining isolators shall have the same having the same static deflection as equipment being isolated.

E. Unless otherwise indicated, all equipment mounted on vibration isolators shall have a minimum operating clearance of 2 inches between the bottom of the equipment or inertia base (and height-saving bracket) and the concrete housekeeping pad (or bolt heads) beneath the equipment. The clearance shall be checked by the Contractor to ensure that no material has been left to short-circuit the vibration isolators. There shall be a minimum 4 inch clearance between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.

F. Piping, ductwork, conduit or mechanical equipment shall be supported from building structure, not hung from or supported on other equipment, pipes, or ductwork.

G. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping, and blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims.

H. All mechanical equipment not specifically identified in this specification that contains rotating or vibrating elements, and any associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or NIS neoprene isolators as appropriate.

I. All wiring connections to mechanical equipment on isolators shall be made with flexible conduit installed in a slack U-shape.

J. Elastomeric isolators that will be exposed to temperatures below 32 degrees F shall be fabricated from natural rubber instead of neoprene.

K. Springs shall be designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.

L. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

M. Refer to Vibration Isolation Schedule at the end of this Section.

3.2 FAN ISOLATION - GENERAL

A. All fans and air handling units shall be mounted on vibration isolators as described herein, as shown on the equipment schedule and on the drawings.

B. All fan equipment shall be leveled with the fans operating before the flexible connectors are attached.
3.3 SUSPENDED FANS, FAN POWERED BOXES, VAV BOXES

A. Units shall be suspended from overhead structure shall be hung on Type SPNH spring isolators. Unless otherwise specified in the Schedule, the static deflection of the isolators shall be 2 inches. Fans shall be suspended from above only if expressly noted as such on the drawings and schedules. Thrust restraint shall be by pre-compressed isolators.

3.5 EXHAUST FANS

A. Exhaust fans on structure shall be supported on Type DDNM isolators.

3.6 VIBRATION ISOLATION OF PIPING

A. All piping connected to equipment installed on spring vibration isolators, except gas and fire protection piping, shall be suspended or supported by Type SPNM or Type SPNH isolators for a minimum distance of 50 feet from vibrating equipment.

B. All piping connected to equipment installed on neoprene vibration isolators shall be either supported on Type DDNM mounts or suspended from the structure on Type DDNH hangers for a minimum distance of 50 feet from vibrating equipment.

C. The first three (3) isolation supports from the rotating or vibrating equipment shall have a static deflection under actual load conditions equal to the static deflection of the isolators supporting the equipment, up to a maximum of 2 inches. Static deflection of remaining isolators shall be 1 inch (spring type only).

D. Where a pipe run connects multiple items of equipment in the mechanical room the pipe isolators for the entire run shall be chosen to suit the connected equipment of greatest static deflection.

E. All chilled water piping and piping greater than 2 inches O.D. located within the building shall be resiliently supported by Type SPNM or Type SPNH vibration isolators in their entirety.

F. Where piping with an O.D. greater than 2 inches runs within a riser common to these spaces, Mason Type ADA or ADAH piping riser guides shall be used for resilient support. Where lateral bracing is required, neoprene riser guides shall be mounted around the pipe to limit lateral movement and to prevent direct contact with the supporting structure.

G. All piping with an O.D. less than or equal to 2 inches supported on or from structure common to the Sanctuary shall be isolated from the structure with sponge neoprene (Armaflex FR) or glass /mineral fiber sleeves between the pipe and pipe clamp or with Type WP pads between the clamp and the structure. When it is compressed, the sleeve shall be not less than 1/8 inch in thickness.

3.7 FLEXIBLE PIPING CONNECTORS

A. Flexible piping connectors shall be installed to connect piping diameter 2 inches or greater to reciprocating or rotating equipment. Where required, anchor cables shall be used (Mason Type ACC or equivalent) to prevent axial elongation. Rigid control rods shall not be used.
B. The Contractor is to exercise extreme care in the selection and placement of these devices to prevent failure of the device. Manufacturer’s installation instructions shall be carefully followed.

3.8 DUCT ISOLATION

A. Ducts shall be connected to fans, fan casings and fan plenums by means of flexible connectors. Flexible duct connectors shall not be used outside the mechanical room unless expressly shown on the drawings.

3.9 SHEET METAL AND PIPING PENETRATIONS OF SHAFTS, FLOOR SLAB AND/OR PARTITIONS

A. There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partitions.

B. All openings around pipes and ducts in the structure surrounding the mechanical equipment and surrounding noise-critical spaces shall be sealed packed with caulking for the full depth of the penetration, as described herein, and as shown on the drawings. This includes all slab penetrations and penetrations of noise critical walls.

3.10 DUCT PENETRATIONS

A. Where each duct passes through a wall, floor or ceiling, there shall be a clear annular space of 1 inch between the duct and structure. After all of the ductwork is installed the Contractor shall check the clearance, pack the voids full depth with mineral fiber batt insulation and caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material. Where there is not sufficient access space to pack around all sides of a duct (for example, at the underside of a slab), place a short stub duct in the wall, pack and caulk around it and then attach the inlet and outlet ducts to each end.

3.11 PIPE PENETRATIONS

A. HVAC DRAIN AND VENT PIPING

1. Where a pipe passes through a wall, ceiling or floor slab, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be 2 inches larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, the Contractor shall check the clearance and correct it, if necessary, to within 1/2 inch. Then the void shall be packed full depth with glass/mineral fiber and sealed at both ends, 1 inch deep, with sealant backed by foam rod.

B. FIRE PROTECTION PIPING

1. Fire protection piping may be sleeved and sealed as described above, or may be grouted and caulked into the structure as follows: before grout has set, rake a groove around the pipe on each side of the wall or slab; groove shall be 1/2 inch wide and 1/2 inch deep. After grout has set, fill groove full depth with sealant.

2. Penetration of sound isolating ceilings by sprinkler pipes and heads shall be sleeved and sealed as described herein. There shall be no rigid connection between ceiling and pipes or heads.

3.12 DAMPERS
A. Dampers shall be installed only where shown on the drawings or approved by the acoustics consultant. All variations in damper locations must be approved in writing by the acoustics consultant.

3.13 ELBOWS

A. All rectangular or round ductwork shall have full radius elbows or except where mitered elbows are shown on the drawings.

B. Where space limitations prevent the installations of full radius elbows, short radius elbows with a minimum two continuous splitter vanes shall be installed. Vane length shall be the entire length of the bend or 36 inches whichever is greater. Provide separate equal size sections for greater lengths.

3.14 WIRING

A. All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with flexible conduit installed in a slack U-shape. This Contractor shall coordinate wiring connections with the Electrical Contractor.

3.15 FIELD QUALITY

A. Contractor shall work in accord with best trade practices, shall fabricate and install all items in accordance with manufacturer's recommendations and Architect's directions, and shall consult with trades doing adjoining work in order to provide an installation of first class quality.

3.16 ADJUSTMENT AND TESTING

A. SITE ACCESS

1. During installation of equipment, Contractor shall arrange for access as necessary for inspection of isolation and noise control equipment by Architect and his representatives.

B. CONTRACTOR'S REPORT

1. The vibration isolation vendor shall inspect and approve the installation of the vibration isolators and shall submit a report to the Owner which verifies that all of the isolation equipment has been properly installed and that the installation is in full conformance with the specification. The report shall record the vibration isolator identification and model or type. For isolators containing steel springs the report shall also record the size and uncompressed height, design static deflection and measured static deflection of the isolators provided.

C. CONSULTANT'S INSPECTION

1. Upon completing installation and adjustment for suitable operation of all work specified under this section, the Contractor shall notify the Architect in writing. The letter shall certify that all work specified under this section is complete, operational and adjusted in every respect, and that all work is ready for the completion checkout. The notification letter shall be accompanied by a copy of the air balancing report and the vibration isolation report.

2. Upon notification of completion, Architect will schedule an inspection by the Acoustics Consultant, who will measure the background noise level with all Mechanical Systems running.
3. For each inspection, Contractor shall perform such functions as are necessary for inspection of the equipment. Background noise level testing must be carried out during late-night hours when ambient noise from outside is at a minimum and the site is otherwise not occupied and no work is under way. Contractor shall turn on and off any and all mechanical equipment during such background noise level testing.

4. If, in the actual installation, any equipment fails to meet the noise or vibration control requirements specified herein, that equipment shall be corrected or replaced without claim for additional payment, inclusive of all labor and material costs. Such corrective measures shall be done within a time schedule specified by the Owner.

3.17 VIBRATION ISOLATION SCHEDULE FOR MECHANICAL EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>BASE TYPE</th>
<th>ISOLATOR TYPE</th>
<th>STATIC DEFLECTION</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Fan Coil Units</td>
<td></td>
<td>SPNH</td>
<td>1 inches</td>
<td></td>
</tr>
<tr>
<td>Fan Powered Boxes</td>
<td></td>
<td>SPNH</td>
<td>1 inches</td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td>Isolation as per specification.</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Warning tags.

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

1.4 COORDINATION
A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS
A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

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

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
B. Letter Color: Black.
C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets or self-tapping screws.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.


C. Background Color: Green.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.5 WARNING TAGS

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

   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
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 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 30 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

C. Pipe Label Color Schedule:

1. Chilled-Water, Condenser-Water, Heating Water, and Refrigerant Piping:
   a. Background Color: Green.

3.4 DUCT LABEL INSTALLATION

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

1. Green with White Lettering: For cold-air supply ducts, hot-air supply ducts, exhaust-, outside-, relief-, return-, and mixed-air ducts.
2. ASME A13.1 Colors and Designs: For hazardous material exhaust.
B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer’s option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 30 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION
SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

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. Balancing Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.

1.3 DEFINITIONS
C. TAB: Testing, adjusting, and balancing.
D. TABB: Testing, Adjusting, and Balancing Bureau.
E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 SUBMITTALS
A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
D. Certified TAB reports.
E. Sample report forms.
F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage an independent TAB entity certified by AABC, NEBB, or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB, or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB, or TABB as a TAB technician.

B. TAB Conference: Meet with Architect, Engineer, Construction Manager and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days’ advance notice of scheduled meeting time and location.

1. Agenda Items:
   b. The TAB plan.
   c. Coordination and cooperation of trades and subcontractors.
   d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer and Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of the new building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide seven days’ advance notice for each test. Include scheduled test dates and times.
B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

**PART 2 - PRODUCTS (Not Applicable)**

**PART 3 - EXECUTION**

**3.1 TAB SPECIALISTS**

A. Subject to compliance with requirements, engage an independent Testing and Balancing Contractor that meets the requirements set forth in this Section.

**3.2 EXAMINATION**

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

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible. Proportional pre-balancing for areas where duct run-outs to air devices and associated dampers are above hard (un-accessible) ceilings shall be acceptable.

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

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

E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

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

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

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
J. Examine terminal units such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

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

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

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

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


B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

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

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

M. For balancing of air handler systems, set up AHUs simulating a dirty filter condition.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Set up air distribution system with the most critical (highest static run) damper wide open during maximum loading to minimize system horsepower requirements and noise.

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

1. Measure total airflow.

   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.  
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Obtain approval from Construction Manager and Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

D. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

E. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.
3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Set up air distribution system with the most critical terminal unit and last damper wide open during maximum loading to minimize system horsepower requirements and noise.

C. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.8 PROCEDURES FOR MOTORS

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

1. Manufacturer's name, model number, and serial number.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.9 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:
   1. Entering- and leaving-water temperature.
   2. Water flow rate.
   3. Water pressure drop.
   4. Dry-bulb temperature of entering and leaving air.
   5. Wet-bulb temperature of entering and leaving air for cooling coils.
   6. Airflow.
   7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Wet-bulb temperature of entering and leaving air.
   3. Airflow.
   4. Air pressure drop.
   5. Refrigerant suction pressure and temperature.
3.11 PROCEDURES FOR OUTSIDE AIR DEMAND CONTROL

A. Outside air is controlled by carbon dioxide sensors that modulate the outside air from 5% (adjustable to allow for the building to be positive pressure) of the outside air volume listed in the schedule to 100% of the outside air volume listed. Set up outside air demand control such that the building is set up to be slightly positive with the toilet exhaust and other continuous general exhaust running without aid of control by BCS so that minimums under normal conditions will always be met.

3.12 TOLERANCES

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

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.

3.13 REPORTING

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

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

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

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

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

1. Pump curves.
2. Fan curves.
3. Manufacturers’ test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

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

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

   1. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Water and steam flow rates.
   3. Duct, outlet, and inlet sizes.
   4. Pipe and valve sizes and locations.
   5. Terminal units.

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

   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches, and bore.
      i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
      j. Number, make, and size of belts.
      k. Number, type, and size of filters.
2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Coil Test Reports:
   1. Coil Data:
      a. System identification.
      b. Location.
      c. Coil type.
      d. Number of rows.
      e. Fin spacing in fins per inch o.c.
      f. Make and model number.
      g. Face area in sq. ft..
      h. Tube size in NPS.
      i. Tube and fin materials.
      j. Circuiting arrangement.

   2. Test Data (Indicated and Actual Values):
      a. Air flow rate in cfm.
      b. Average face velocity in fpm.
      c. Air pressure drop in inches wg.
      d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
      e. Return-air, wet- and dry-bulb temperatures in deg F.
      f. Entering-air, wet- and dry-bulb temperatures in deg F.
      g. Leaving-air, wet- and dry-bulb temperatures in deg F.
      h. Water flow rate in gpm.
      i. Water pressure differential in feet of head or psig.
      j. Entering-water temperature in deg F.
      k. Leaving-water temperature in deg F.
      l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.

o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btu/h.
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Air flow rate in cfm.
   i. Face area in sq. ft..
   j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):
   a. Heat output in Btu/h.
   b. Air flow rate in cfm.
   c. Air velocity in fpm.
   d. Entering-air temperature in deg F.
   e. Leaving-air temperature in deg F.
   f. Voltage at each connection.
   g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

   a. System and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft..
   g. Indicated air flow rate in cfm.
   h. Indicated velocity in fpm.
   i. Actual air flow rate in cfm.
   j. Actual average velocity in fpm.
   k. Barometric pressure in psig.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

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

2. Test Data (Indicated and Actual Values):

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

K. Instrument Calibration Reports:

1. Report Data:

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

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   c. Verify that balancing devices are marked with final balance position.
   d. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Engineer, Construction Manager, and Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Engineer, Construction Manager, and Commissioning Authority.
3. Engineer, Construction Manager, and Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

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

D. Prepare test and inspection reports.

3.16 ADDITIONAL TESTS

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

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.
END OF SECTION
SECTION 23 07 00
MECHANICAL INSULATION

PART 1 - GENERAL

1.1 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. Insulation Materials:
   a. Flexible elastomeric.
   b. Mineral fiber.
   c. Polyolefin.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
7. Sealants.
8. Factory-applied jackets.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.

B. Related Sections:

1. Division 22 Section "Plumbing Insulation."
2. Division 23 Section "Metal Ducts" for duct liner.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and
jackets (both factory and field applied, if any).

B. Shop Drawings:

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

C. Qualification Data: For qualified Installer.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

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

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Duct Wrap.
   d. Owens Corning; All-Service Duct Wrap.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. For equipment applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Johns Manville; 800 Series Spin-Glas.
   c. Knauf Insulation; Insulation Board.
   d. Owens Corning; Fiberglas 700 Series.

G. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000 Pipe Insulation.
   d. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with
ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Owens Corning; Fiberglas Pipe and Tank Insulation.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Armacell LLC; Tubolit.
   b. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
   c. RBX Corporation; Therma-cell.

2.2 INSULATING CEMENTS


1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Insulco, Division of MFS, Inc.; Triple I.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

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

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Insulco, Division of MFS, Inc.; SmoothKote.
   c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
B. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-96.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA Inc.; Aerosol.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-82.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. ASJ Adhesive and FSK Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-82.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content acceptable to LEED when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-35.
   b. Foster Products Corporation, H. B. Fuller Company; 30-90.
   c. ITW TACC, Division of Illinois Tool Works; CB-50.
   d. Marathon Industries, Inc.; 590.
   e. Mon-Eco Industries, Inc.; 55-40.
   f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.


2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content acceptable to LEED s when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-52.
   b. Foster Products Corporation, H. B. Fuller Company; 81-42.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.

4. Service Temperature Range: Minus 50 to plus 180 deg F.


2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide products by one of the following:
a. Childers Products, Division of ITW; CP-76.
b. Foster Products Corporation, H. B. Fuller Company; 30-45.
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc.; 44-05.
e. Pittsburgh Corning Corporation; Pittseal 444.
f. Vimasco Corporation; 750.

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants:

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   a. Products: Subject to compliance with requirements, provide products by one of the following:
      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
3. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
   1. Products: Subject to compliance with requirements, provide products by one of the following:
      a. Johns Manville; Zeston.
      c. Proto PVC Corporation; LoSmoke.
      d. Speedline Corporation; SmokeSafe.
   2. Adhesive: As recommended by jacket material manufacturer.

C. Metal Jacket:
   1. Products: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products, Division of ITW; Metal Jacketing Systems.
      b. PABCO Metals Corporation; Surefit.
      c. RPR Products, Inc.; Insul-Mate.
      a. Finish and thickness are indicated in field-applied jacket schedules.
      b. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      c. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.
   1. Products: Subject to compliance with requirements, provide products by one of the following:
      a. Polyguard; Alumaguard 60.
2.9 **TAPES**

**A. ASJ Tape:** White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. **Products:** Subject to compliance with requirements, provide products by one of the following:
   
a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   b. Compac Corp.; 104 and 105.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. **Width:** 3 inches.
3. **Thickness:** 11.5 mils.
4. **Adhesion:** 90 ounces force/inch in width.
5. **Elongation:** 2 percent.
6. **Tensile Strength:** 40 lbf/inch in width.
7. **ASJ Tape Disks and Squares:** Precut disks or squares of ASJ tape.

**B. FSK Tape:** Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. **Products:** Subject to compliance with requirements, provide products by one of the following:
   
a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. **Width:** 3 inches.
3. **Thickness:** 6.5 mils.
4. **Adhesion:** 90 ounces force/inch in width.
5. **Elongation:** 2 percent.
6. **Tensile Strength:** 40 lbf/inch in width.
7. **FSK Tape Disks and Squares:** Precut disks or squares of FSK tape.

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

1. **Products:** Subject to compliance with requirements, provide products by one of the following:
   
a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   b. Compac Corp.; 120.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
   d. Venture Tape; 3520 CW.

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

A. Bands:

1. Products: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products; Bands.
   b. PABCO Metals Corporation; Bands.
   c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.


B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   a. Products: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; CD.
      3) Midwest Fasteners, Inc.; CD.
      4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. Products: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
b. **Baseplate:** Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. **Spindle:** Copper- or zinc-coated, low carbon steel, Aluminum, or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

d. **Adhesive:** Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. **Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers:** Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. **Products:** Subject to compliance with requirements, provide products by one of the following:

      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

   b. **Baseplate:** Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

   c. **Spindle:** Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

   d. **Adhesive:** Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. **Self-Sticking-Base Insulation Hangers:** Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. **Products:** Subject to compliance with requirements, provide products by one of the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
      2) GEMCO; Press and Peel.
      3) Midwest Fasteners, Inc.; Self Stick.

   b. **Baseplate:** Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

   c. **Spindle:** Copper- or zinc-coated, low carbon steel, Aluminum, and Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

   d. **Adhesive:** Adhesive-backed base with a peel-off protective cover.

6. **Insulation-Retaining Washers:** Self-locking washers formed from 0.016-inch- thick, galvanized-steel, aluminum, and stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. **Products:** Subject to compliance with requirements, provide products by one of the following:

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.
b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

1) GEMCO.
2) Midwest Fasteners, Inc.

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

D. Wire: 0.080-inch nickel-copper alloy or 0.062-inch soft-annealed, stainless steel or 0.062-inch soft-annealed, galvanized steel.

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

b. Childers Products.
c. PABCO Metals Corporation.
d. RPR Products, Inc.

2.11 CORNER ANGLES

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

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATION

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.
D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Pipe: Install insulation continuously through floor penetrations.

3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3.6 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over compress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

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

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

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

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

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

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

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

3.9 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.10 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.


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

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

   D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

   1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.Extent of inspection shall be limited to three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

   2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

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

3.12 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation (unless noted to be lined):
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in non-conditioned space.
   4. Indoor, exposed return located in non-conditioned space.
   5. Outdoor, concealed supply and return.
   6. Outdoor, exposed supply and return.

B. Items Not Insulated:
   1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1 as outlined in “Metal Ducts” section.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums and casings.
   4. Flexible connectors.
   5. Vibration-control devices.
   6. Factory-insulated access panels and doors.

3.13 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round supply-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density, R-5 minimum.

B. Concealed, rectangular, supply-, return, and outside-air duct shall be lined.

C. Exposed, rectangular and round supply-, return, and outside-air duct shall be lined.

D. All transfer boots and relief hood ductwork/boots shall be lined.

E. Exhaust ductwork:
   1. External duct insulation (wrap) for first 10 feet of length from roof or wall penetration.
   2. As noted on plans/details.

3.14 OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Exposed, rectangular, supply-air and return-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density. With vapor barrier and 0.024 inch thick stucco embossed aluminum field applied jacket. Apply insulation in addition to required duct liner.
3.15  PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.16  INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be one of the following:
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   d. Polyolefin: 1 inch thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch thick.

3.17  OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch thick. Aluminum jacket

3.18  INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

END OF SECTION
SECTION 23 08 00
COMMISSIONING OF HVAC

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes commissioning requirements for HVAC&R systems, assemblies, and equipment including:
   1. Building Automation System
   2. Air Handlers and distribution systems including terminal units
B. Related Sections:
   1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for HVAC testing and balancing requirements.

1.3 DEFINITIONS
A. ACG – AABC Commissioning Group
B. BCA – Building Commissioning Association
C. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
D. Commissioning Team: Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, the Commissioning Authority (CxA), representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
E. CxA: Commissioning Authority.
G. Independent: Not associated or financially related to – with the exception of the single project contractual arrangement for this project.
H. NEBB – National Environmental Balancing Bureau
I. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean “as-built” systems, subsystems, equipment, and components.

1.4 COMMISSIONING AUTHORITY QUALIFICATIONS
A. Commissioning Authority (CxA) shall be independent of the design and construction team members and have firm and individual commissioning certifications from one of the following organizations:
   1. Building Commissioning Association
   2. AABC Commissioning Group
   3. NEBB
1.5 **SUB CONTRACTOR'S RESPONSIBILITIES**

A. Perform commissioning tests at the direction of the CxA for:
   1. Rooftop A/C units and distribution systems
   2. Dedicated Outside Air Units.
   4. Building exhaust systems.
   5. Building Domestic Water Heating Systems

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.6 **CxA'S RESPONSIBILITIES**

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract including
   1. Rooftop A/C units and distribution systems
   2. Split system A/C units and ductless split systems.
   3. Building exhaust systems.

B. Attend construction phase controls factory witness test meeting.

C. Direct commissioning testing.

D. Verify testing, adjusting, and balancing of Work are complete.

E. Provide test data, inspection reports, and certificates.

1.7 **COMMISSIONING DOCUMENTATION**

A. Provide the following information to the CxA for inclusion in the commissioning plan:
   1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
   2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
   3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
   4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
   5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
   6. Test and inspection reports and certificates.
   7. Corrective action documents.
   8. Verification of testing, adjusting, and balancing reports.

1.8 **SUBMITTALS**

A. From CxA to Engineer:
   1. Certificates of Commissioning Certification
2. Preliminary Commissioning Plan
3. Final Commissioning Plan
4. Final Commissioning Report

B. From Contractors to CxA:
1. Certificates of readiness.
2. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION
A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
E. Inspect and verify the position of each device and interlock identified on checklists.
F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION
A. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
   1. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
   2. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.
   3. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS
A. Provide technicians, instrumentation, and tools to perform commissioning tests at the direction of the CxA.
B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. The CxA may direct that set points be altered when simulating conditions is not practical.

G. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

H. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Systems Testing: Provide technicians, instrumentation, tools, and equipment to test performance of mechanical systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

B. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

END OF SECTION
PART 1 - GENERAL

1.1 SCOPE

A. The controls and instrumentation and energy management system as specified in this Section shall be provided as an allowance. The specified amount for the allowance is indicated in Section 012100-ALLOWANCES. The Mechanical Contractor shall include this allowance as part of his bid price, and shall add overhead and profit to this allowance figure for coordinating the work of the controls instrumentation and energy management system. The following Specifications describe work to be provided for the controls instrumentation and energy management system.

1.2 RELATED SECTIONS

A. SECTION 23 09 13, BAS Instrumentation and Control Devices
B. SECTION 23 09 13.13, BAS Actuators and Operators
C. SECTION 23 09 13.23, BAS Sensors and Transmitters
D. SECTION 23 09 13.43, BAS Control Dampers
E. SECTION 23 09 23, BAS Direct Digital Control System

1.3 REFERENCES

A. American National Standards Institute (ANSI)
   .1 ANSI/ISA 5.5-1985 Graphic Symbols for Process Displays.
   .2 ANSI/IEEE 260.1 2004, Standard Letter Symbols for SI and Certain Other Units of Measurements (SI Units, Customary Inch Pound Units and Certain Other Units).

1.4 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms used in BAS.
   .3 BAS – Building Automation System
   .4 EMCS – Energy Management and Control System
   .5 GUI – Graphical User Interface
   .6 HVAC - Heating, Ventilation, Air Conditioning
   .7 I/O - Input/output
.8 ISA - Industry Standard Architecture
.9 O&M - Operation and Maintenance

1.5 PERMITS AND FEES

A. In accordance with General Conditions of Contract.
B. Submit certificate of acceptance from authority having jurisdiction to Owner.

1.6 GENERAL DESCRIPTION

A. Refer to control schematics for general system architecture.
B. Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:
   1. Control devices as listed in I/O Summaries.
   2. Peripheral devices.
   3. Complete operating and maintenance manuals and field training of operators, programmers and maintenance personnel.
   4. Acceptance tests, technical support during commissioning, full documentation.
   5. Wiring interface co-ordination of equipment supplied by others.
   6. Miscellaneous work as specified in these sections and as indicated.

1.7 US CUSTOMARY MEASUREMENT REFERENCES

B. Provide required adapters between US Customary and Metric components.

1.8 STANDARDS COMPLIANCE

A. All equipment and material to be from manufacturer’s regular production, UL and/or ULC or CSA certified, manufactured to standard quoted plus additional specified requirements.
B. Where UL and/or ULC or CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
C. Submit proof of compliance to specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.
D. In lieu of such evidence, submit certificate from testing organization, approved by Owner, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
1.9 WORK INCLUDED

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating digital communicating temperature controls system. This shall include HVAC and Lighting Controls, and all reporting and maintenance management functions related to normal building operations all as indicated on the Drawings or elsewhere in this Specification.

B. Provide a new building system to control and monitor the building’s mechanical and electrical systems.

C. Provide control valves, control dampers (gravity, fire and smoke control dampers by others), flow switches, thermal wells for temperature control, and air flow stations as necessary.

D. Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry, pneumatic (as required) and electrical installation, programming, start up, test and validation acceptance documentation, as-built documentation, maintenance manuals and system warranties.

E. All labor, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.

F. The work covered by this specification and related sections consists of providing shop drawings, equipment, labor, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

1. The preparation of submittals and provision of all related services.

2. Furnish and install all to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

3. Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.

4. Perform acceptance tests and commissioning as indicated.

5. Provide full documentation for all applications and equipment.

6. Miscellaneous work as indicated in these specifications.
1.10 WORK BY OTHERS
A. Setting in place of valves and dampers, access doors, flow meters, water pressure and differential taps, flow switches, thermal wells, fire and smoke control dampers, air flow stations, and current transformers shall be by others.

B. Duct smoke detectors shall be provided under Division 28. Connection of auxiliary terminals of duct smoke detectors shall be wired to the BAS for monitoring purposes only by this section.

C. High and low temperature thermostats shall be provided by this section.

D. Switches, and power wiring to motors, starters, thermal overload switches, and contactors, is specified in Division 28. This Section includes the furnishing and installation of controls and wiring for automatic controls, electric damper and valve operators, terminal control units, interlocks, starting circuits, and wiring to power consuming control devices.

1.11 BAS CONTRACTOR QUALIFICATIONS
A. Within 14 days of award of the contract the BAS contractor is to:
   1. Provide proof of having a local office within 50 miles of project for at least 5 years, staffed by trained personnel capable of providing instruction, routine maintenance, emergency service on systems,
   2. Provide record of successful installations of similar size, performed by Contractor submitting the tender, showing successful experience with similar computer based systems.
   3. Provide proof of having access to local supplies of essential parts and provide 7 year guarantee of availability of compatible spare parts after manufacturer's declaration of obsolescence.
   4. Provide Profiles for each employee who will be involved in this project.

1.12 SYSTEM DESIGN RESPONSIBILITY
A. Design and provide all conduit and wiring linking all elements of system, including future capability.

B. Design and provide all material for interfaces to existing pneumatic controls where applicable.

C. Location of controllers to be approved by Owner prior to installation.

D. Provide utility power or emergency power where directed and/or indicated on drawings, to controllers.
PART 2 - PRODUCTS

2.1 QUALITY ASSURANCE

A. All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:2008 manufacturer, for a minimum duration of 5 years, at time of bid.

B. The Building Automation System shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be Factory Authorized in good standing with the Manufacturer. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

1. Upon request, installer shall present records of successful completion of factory training courses including course outlines.

2. Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.

PART 3 - EXECUTION

3.1 COORDINATION

A. All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer / Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.

B. Organize all your sub-contractors and ensure that they maintain the schedule.

C. Full cooperation shall be shown with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.

D. Notify Engineer/Construction Manager of any changes to the schedule. Send any schedule changes and weekly progress reports via e-mail to Engineer/Construction Manager.

E. Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference.

F. When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

3.2 SUPERVISION OF PERSONNEL

A. Maintain qualified personnel and supporting staff at this project with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.

B. Supervisory personnel and their qualifications are subject to the approval of the Owner.

C. All personnel working on-site shall sign in as required by the Owner and shall wear company identification.
D. When requested and for whatever reason, remove personnel and/or support staff from project. Take immediate action.

3.3 SYSTEM DESIGN AND RESPONSIBILITY

A. The drawings do not show conduit size or wire type to link the various elements of the system.
   1. The BAS contractor is responsible for designing these links in view of the present and future capabilities.

B. The Contractor is responsible for supplying sufficient Controllers of all types to meet the intent of the specification.

C. The quantity and point content of the Controllers must be approved by the Engineer prior to point installation.

3.4 PRODUCTS

A. Materials and equipment shall be essentially the catalogued products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest standard design that complies with the specification requirements.

B. Where two units of the same class of equipment are required, these units shall be products of a single manufacturer, and the component parts of the system shall be the products of a single manufacturer.

C. Each major component of equipment shall have the manufacturer's name and address and the model and serial number on a nameplate securely attached in a conspicuous place.

3.5 ELECTRICAL WORK, WIRING AND SAFETY

A. Electrical work shall be in accordance ANSI/NFPA 70 and the local Electrical Code.

B. Based on project location, Regional Regulation Compliance Certifications (CSA C22.1) will be required.

C. Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel.

D. All wiring shall conform to the most stringent requirements of the local electrical authority having jurisdiction. Refer to Division 26 for electrical requirements, codes and regulations.

E. All wiring associated with and required by the BAS shall be the responsibility of this contractor.
   1. The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system.
   2. If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.
3.6 MANUFACTURER’S RECOMMENDATIONS

A. Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.7 NAMEPLATES

A. Nameplates shall be provided for all control items listed or shown in the submittal and approved control diagrams.

B. Each inscription shall identify its function, such as "mixed air controller", "cold deck sensor" in official languages etc. and when applicable, its position.

1. Size of nameplates shall be 1 inch by 3 inches minimum.

2. Lettering shall be minimum ¼ inch high normal black lettering.

3. Submit duplicate samples of identification tags and lists of wording proposed for approval.

3.8 PRELIMINARY DESIGN REVIEW

A. The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information:

1. Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.

2. Provide product data sheets and a technical description of all direct digital controller hardware required to meet specifications listed herein.

3. Provide an overview of the BAS contractor’s local/branch organization, local staff, recent related project experience with references, and local service capabilities.

4. Provide information on the BAS contractor’s project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

5. Project Schedule of work indicating:

a. Intended sequence of work items

b. Start date of each work item

c. Duration of each work item

d. Planned delivery dates for ordered material and equipment and expected lead times

e. Milestones indicating possible restraints on work by other trades or situations
3.9 SUBMITTALS

A. Within 45 days of award of contract and before start of construction, submit 3 hard copies and 1 soft copy of manufacturer’s information and shop drawings.

   1. Drawings to be in AutoCAD or VISIO and Sequence of Operations and Points List (Input/output Summary) shall be in Word and Excel format (latest versions) structured using menu format for easy loading and retrieval on the OWS.

B. Provide in completely coordinated and indexed package to assure full compliance with the contract requirements.

   1. Piecemeal submittal of data is not acceptable and such submittals will be returned without review.

   2. Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work.

   3. Arrange the submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended.

   4. Submittals for each manufactured item shall be manufacturer’s descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalog cuts, and shall include the manufacturer’s name, trade name, catalog model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

C. Control System Shop Drawings

   1. Schematic diagram of each controlled system. Label control points with point names.

   2. Bill of Material 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.

   3. Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.

   4. Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.

   5. Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point; and manufacturer’s recommended installation instructions and procedures for each type of sensor and/or transmitter.
3.10 AS-BUILT DOCUMENTATION (OPERATING AND MAINTENANCE (O&M) MANUALS)

A. As-built documentation shall consist of 4 hard copies and one soft copy for all information described below.

B. The final documentation package shall include:
   1. Hard and soft copies of all control drawings.
   2. Manufacturer’s technical data sheets for all hardware and software.
   3. Factory operating and maintenance manuals with any customization required.
   4. Soft copies of programming and front-end software and each controller’s database. Hard copy output of programming is not necessary.
   5. Provide clear, concise, printed and soft copy descriptions of all control sequences in the working language.
   6. Soft copy text files shall be in Microsoft Word format.
   7. Copy of all graphics files.

C. Each instruction and reference manual shall be bound in hardback, 3 ring, binders or an approved equivalent shall be provided to the Engineer.
   1. Binders to be no more than 2/3 full.
   2. Each binder to contain index to full volume.
   3. One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance.
   4. The identification of each manual’s contents shall be inscribed on the cover and spine.
   5. The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system.
   6. The manuals shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject.
   7. Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph.
   8. Manuals and specifications shall be furnished which provide full and complete coverage of the following subjects:
      a. Operational Requirements: This document shall describe in concise terms, all the functional and operational requirements for the system and its functions that have been implemented. It shall be written using common terminology for building
operation staff and shall not presume knowledge of digital computers, electronics or in-depth control theory.

b. System Operation: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.

c. Maintenance: Documentation of all maintenance procedures for all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module. This shall include calibration, maintenance, and repair or replacement of all system hardware.

d. Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures. A provision for the measurement or observation of results, based on the published test specification, forms the test reports. The procedures record and the results of these exercises shall be conveniently bound and documented together.

e. Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system. This shall include all information required to ensure necessary coordination of hardware and software changes, data link or message format/content changes, and sensor or control changes in the event system modification are required, and to fully document such new system configurations.

3.11 MANUFACTURER TRAINING

A. Manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the Owner or his designated agent.

1. Such training shall be of the same curriculum as the training courses provided by the manufacturer to the Contractor.

2. A manufacturer certified instructors shall give all training classes.

3. A list of training courses with detailed course outline and duration with the associated cost shall be provided as part of the BAS submittals.

END OF SECTION
SECTION 23 09 13

BAS INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00, BAS Instrumentation and Control
B. SECTION 23 09 13.13, BAS Actuators and Operators
C. SECTION 23 09 13.23, BAS Sensors and Transmitters
D. SECTION 23 09 13.33, BAS Control Valves
E. SECTION 23 09 13.43, BAS Control Dampers
F. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 COMPUTER HARDWARE

A. General Description:
   .1 The computer shall consist of commercially available general-purpose equipment manufactured by a recognized manufacturer with factory authorized service centers within 75 miles of the job site.
   .2 The server shall be provided for centralized system control, information management, alarm management and data base management functions.
   .3 All real time control functions shall be resident in the standalone Network Control Unit (NCU) and local controllers (LCUs and TCUs).

B. Provide a Server as detailed herein complete with software, as described in Section 23 09 13.

C. Provide Operator workstations as detailed herein complete with software, as described in Section 23 09 13.

D. The system shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users. The BAS shall be provided with a minimum of 32 user licenses.

E. Provide three copies of all Programming Software required for programming LCUs and TCUs as described herein.

F. Any computer with access to the BAS LAN shall be capable of displaying the systems in a graphical and dynamic format utilizing a standard web browser. Screen refresh shall be automatic. Manual refresh is not acceptable.
2.2 SERVER HARDWARE REQUIREMENTS

A. The Server shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB ports. A minimum 21”, HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

B. The server operating system
1. shall be one of:
   a. Windows 7 Professional 64bit
   b. Windows 7 Ultimate 64bit
   c. Windows 8.1 64bit
   d. Windows Server 2012 64bit
2. With VM support
3. With the most recent service packs and system updates.
4. Selected based on availability and project requirements.

C. Latest version of Symantec Antivirus Software that includes a 3 year subscription service to the Symantec software.

D. Acceptable Manufacturers are:
1. Dell
2. Lenovo
3. HP (Hewlett Packard)

E. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

F. The server will be located in the MDF room on level one.

G. The server shall support all Network Control Units (NCU), OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.

2.3 NOTEBOOK WORKSTATION REQUIREMENTS

A. The Notebook Workstation shall be a minimum Intel Core i3 Dual core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6Gb/s transfer rate. It shall include a minimum 32X CD-ROM drive, and 3-USB ports, minimum 15” LED display capable of as a minimum 1024 x 768 resolution.

B. The operating system
1. shall be one of:
   a. Windows 7 Professional 64bit
   b. Windows 7 Ultimate 64bit
   c. Windows 8.1 64bit
2. With the most recent service packs and system updates.
3. Selected based on availability and project requirements.

C. Acceptable Manufacturers are:
1. Dell
2. Lenovo
3. HP (Hewlett Packard)

D. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

E. Provide 1 (one) Notebook Workstation. Turn over the notebook workstations to the owner at time of training.
2.4 UNINTERRUPTABLE POWER SUPPLIES

A. Provide the OWS, Server, and each NCU with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

B. Acceptable Manufacturer is APC.

2.5 OPERATOR SOFTWARE

A. Operating System: Provide Operator software. The software shall run on Microsoft Windows 7 Professional or Ultimate.

B. The software shall employ browser-like functionality for ease of navigation.
   1. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database.
   2. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills.
   3. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

C. Real-Time Displays.
   1. Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.
      a. Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.
      b. The graphic shall provide for the ability to command each point, including both timed and permanent overrides.
      c. Provide for all information represented in the graphics in an associated graphical table with links to the equipment graphics and command-able points.
      d. Sample graphics shall be provided as part of the submittals for approval by owner.

D. The Operator software, shall at a minimum, support the following graphical features and functions:
   1. Graphic screens shall be developed using GIF, PNG, JPG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
   2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, colour spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
   3. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.

E. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
   1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
   2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

F. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
G. Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.

H. System Configuration.
1. At a minimum, the Operator software shall permit the operator to perform the following tasks, with proper password access:
   a. Create, delete or modify control strategies.
   b. Add/delete objects to the system.
   c. Tune control loops through the adjustment of control loop parameters.
   d. Enable or disable control strategies.
   e. Generate hard copy records or control strategies on a printer.
   f. Select points to be alarm-able and define the alarm state.
   g. Select points to be trended over a period of time and initiate the recording of values automatically.

I. On-Line Help.
1. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
   a. On-line help shall be available for all applications and shall provide the relevant data for that particular screen.
   b. Additional help information shall be available through the use of hypertext.
   c. All system documentation and help files shall be in HTML format.

J. Security.
1. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data.
2. System security shall be selectable for each operator.
3. The system administrator shall have the ability to set passwords and security levels for all other operators.
4. Each operator password shall be able to restrict the operators’ access for viewing and/or changing each system application, full screen editor, and object.
5. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
6. This auto log-off time shall be set per operator password.
7. All system security data shall be stored in an encrypted format.

K. System Diagnostics.
1. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.
2. The failure of any device shall be annunciate to the operator.

L. Alarm Console.
1. The system shall be provided with a dedicated alarm window or console.
   a. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.
   b. The use of the Alarm Console can be enabled or disabled by the system administrator.
      1) When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.
   c. This window will notify the operator of new alarms and un-acknowledged alarms.
   d. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

M. Operator’s software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming.
1. This system shall provide the capability to configure controller binary and analog inputs/outputs.
N. The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.
   2. No proprietary graphics generation software shall be needed.

O. Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

P. The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information.
   1. All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console.
   2. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection.
   3. The facility shall be provided to permit the operator to perform the following tasks:
      a. Automatic logging of digital alarms and change of status message.
      b. Automatic logging of all analog alarms.
      c. System changes (alarm limits, set-points, alarm lock-outs, etc.).
      d. Display specific points as requested by the operator.
      e. Provide reports as requested by the operator and on Scheduled basis where so required.
      f. Display graphics as requested by the operator.
      g. Display of help information.
      h. Provide trend logs as required by the operator.
      i. Provide manual control of digital and analog outputs as required by the operator.
      j. Direct the hard copy output of information to the device selected by the operator.
      k. Data displayed on monitor to cyclic update as appropriate.

Q. Online changes:
   1. Alarm limits.
   2. Setpoints.
   3. Dead-bands
   4. Changes/deletions/additions of points.
   5. Control and change of state changes.
   6. Time of day, day, month, year.
   7. Control loop control description changes for NCU based CDM's.
   8. Control loop tuning changes
   9. Schedule changes
   10. Changes/additions/deletions to system graphics
   11. Changes/additions/deletions to total systems

R. It shall be possible for the operator to override automatic analog and digital output commands.
   1. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.
   2. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.
   3. It shall be possible for the operator to place any computed system setpoint to a computed basis as and when required.
   4. All above functions shall operate under the password protection system.

S. A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows:
   %, °C, KPA, KW, KWH, L/S, CFM, °F, and PSI.
1. The descriptions shall be alterable from the OWS console with the system on-line.

T. Upon operator’s request, the system shall present the condition of any single point, any system, and area or the whole system on printer or Monitor.
1. The output device shall be by operator’s choice.
2. Analog values and status displayed on the Monitor shall be updated whenever new values are received.
3. Points in alarm shall be flagged by blinking, inverse video different colour, bracketed, or by some other means to differentiate them from points not in alarm.

U. Error Messages
1. Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of BAS.
2. Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

V. Password Protection
1. Provide security system that prevents unauthorized use unless operator is logged on.
   a. Access shall be limited to operator’s terminal functions unless user is logged on, including displays as outlined above.
2. Each operator’s workstation shall provide security for 100 users minimum.
   a. Each user shall have an individual User ID, User Name and Password.
3. Entries are alphanumeric characters only and are case sensitive (except for User ID).
4. User ID shall be 8 characters.
5. User Name shall be a maximum of 29 characters, and Password shall be a maximum of 8 characters long.
6. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access.
7. All passwords, user names, and access assignments shall be adjustable online at the operator’s terminal.
8. Each user shall also have a set security level, which defines access to displays and individual objects the user may control.
9. System shall include 10 separate and distinct security levels for assignment to users.

W. Trend Data
1. System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator’s workstation (server) hard disk.
   a. Archived files shall be appended with new sample data, allowing samples to be accumulated over 3 years.
   b. Systems that write over archived data shall not be allowed, unless limited file size is specified.
   c. Samples may be viewed at the operator’s terminal in a trend log.
   d. Logged data shall be stored in spreadsheet format.
   e. Operator shall be able to scroll through all trend log data.
   f. System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically.
   g. All trend log information shall be displayed in standard engineering units.
2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours and these Graphs shall show object type value relative to time.
3. Operator shall be able to change trend log setup information.
   a. This includes the information to be logged as well as the interval at which it is to be logged.
   b. Minimum interval of 1 minute.
   c. All input, output, and value object types in the system may be logged.
   d. All operations shall be password protected.
e. Setup and viewing may be accessed directly from any and all graphics object is displayed on.

4. System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk.
   a. Archive files shall be appended with the new data, allowing data to be accumulated over several years.
   b. Systems that write over archived data shall not be allowed unless limited file size is specified.
   c. System shall automatically open archive files as needed to display archived data when operator scrolls through the data.
   d. Display all energy log information in standard engineering units.

5. System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time.
   a. All data shall be stored in spreadsheet format for direct use by third-party spreadsheet or other database programs.
   b. Operation of system shall not be affected by this operation.

6. Operator shall be able to change the energy log setup information.
   a. Including the meters to be logged, meter pulse value, and the type of energy units to be logged.
   b. All meters monitored by the system may be logged.
   c. All operations shall be password protected.

X. Graphics
1. The operator's workstation shall display all data associated with the project.
   a. The operator’s terminal software shall accept, GIF, PNG, JPG and ICO format graphic files for display purposes.
   b. Graphic files shall be created using scanned, full colour photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.
   c. Operator’s workstation shall display all data using 3-D graphic representations of all mechanical equipment.
   d. Displays can be used as templates to produce other displays.

2. System shall be capable of displaying graphic file, text, and dynamic object data together on each display.
   a. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.
   b. All information on any display shall be dynamically updated without any action by the user.
   c. Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.
   d. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

3. All displays shall be generated and customized in such a manner by the local DDC system supplier that they fit the project as specified.
   a. Canned displays shall not be acceptable.
   b. Displays shall use Standard English for labelling and readout.
   c. Systems requiring factory programming for graphics are specifically prohibited.
   d. The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.

4. Binary objects shall be displayed as ON/OFF/NULL or with customized text.
   a. Text shall be justified left, right or centre as selected by the user.
   b. Allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic.
   c. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm.
d. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object’s status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp).

e. Additionally, allow binary objects to be displayed as an animated graphic.

5. Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

a. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation.

b. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF.

c. Allow operator to change bitmap file assignment and also create new and original bitmaps online.

d. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator.

e. Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.

6. Analog objects shall be displayed with operator modifiable units.

a. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic.

b. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps.

c. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint.

d. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box.

e. Selection for display type shall be individual for each object.

f. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad.

7. Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value.

a. For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint.

b. All editing and area assignment shall be created or modified online using simple icon tools.

8. A customized menu label (push-button) shall be used for display selection.

a. Menu items on a display shall allow penetration to lower level displays or additional menus.

b. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item.

c. Each display may be protected from viewing unless operator has appropriate security level.

d. A separate security level may be assigned to each display and system object.

9. A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

10. Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.

a. The presentation will contain displays for:
   1) Site Overview
   2) Specific Building(s)
   3) Floor plates within Building(s)
   4) Each controlled Zone
   5) Each controlled System or Sub-System

b. All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)
c. Clicking on a building in the Site Overview displays the specific building display.

d. Clicking on a floor, displays the floor plate display.

e. Clicking on a zone, displays the specific control system for that zone.

f. Clicking on a specific system or sub-system coarse representation at the floor plate display level displays a detailed presentation of the system or sub-system.

11. Displays are stored on the server and may be modified on site or via remote communications.

12. Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

Y. Alarms

1. Operator's terminal shall provide audible, visual, electronic and printed means of alarm indication.

2. Any alarm may be handled based on its individual or assigned class actions.

a. Actions are, but not limited to

1) Displayed on the Alarm console.

   a) The system shall be provided with a dedicated alarm window or console.

   b) This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

   c) The use of the Alarm Console can be enabled or disabled by the system administrator.

   d) When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

   e) This window will notify the operator of new alarms and un-acknowledged alarms.

   f) Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

   g) Printout of alarms shall be sent to the assigned terminal and port.

2) Delivery by electronic mail (e-mail).

   a) Sent via e-mail to one or more recipients.

3) Printed.

   a) Printed on local or network printer.

3. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal.

   a. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

4. Alarm messages shall be in user-definable text (English or other specified language) and shall be entered either at the operator's terminal or via remote communication.

Z. Scheduling

1. Operator's terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

   a. This includes all ON/OFF times (to the minute) for each day's events.

2. Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

   a. These specialty schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, again allowing easy data entry.

   b. Exception schedule data is entered by the following methods:

      1) date entries (one day entries)

      2) date-to-date (a range or span of days)

      3) by weekday (for example, a given day of a given week each month)

   c. User shall be able to scroll easily through the months for each year as a minimum.

3. At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
4. Archiving
5. Store back-up copies of all controller databases in at least one OWS and the server.
6. Provide continuous supervision of integrity of all controller databases.
   a. Database back up and downloading to occur over LAN without operator intervention.
7. Operator to be able to manually download entire controller database or parts thereof.

AA. Reports
1. Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.
   a. If display output (Monitor) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report.
   b. Output to be sorted by area, system point.
2. Periodic/Automatic Report:
   a. Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.
   b. The software will allow the operator to modify the periodic/automatic reporting profile at any time.
3. As a minimum, the following reports shall be configured on the system:
   a. Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency and it shall be possible to select points on the following basis:
      1) All points in all areas
      2) Area (all points in area)
      3) Area system (all points in system)
      4) Area system point (individual point)
      5) System (all points by system and point type)
      6) System point (all points by system and point type)
      7) Area point (all points by area and point type).
   b. Summary Report:
      1) To permit the display or printing of the dynamic values for the user specified points.
         a) Reports to be available on same basis as dynamic reports.
         b) Output will be to the user selected output device.
   c. Trend Reports:
      1) To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.
   d. Historical Data Collection:
      1) Provision shall be made to ensure historical data is not lost.
         a) The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided.
         b) Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.
   e. Critical Alarm Summary:
      1) Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.
   f. Maintenance Alarm Summary:
      1) Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.
   g. Alarm Summary:
      1) Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.
   h. Disable Point Summary:
1) Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

i. Run Time Summary:
1) Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

j. Schedule Summary:
1) Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

k. User Record Summary:
1) Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

BB. Utility Software
1. Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.
2. Enter all soft copy submissions; including "Record" drawings as specified herein] in OWS.

2.6 BAS CONTROLLERS

A. Controllers – BACnet Protocol{MSTP}
1. Provide BACnet Controllers that BACnet Testing Laboratory listed (v12 or later) as specified herein:{MSTP}
   a. BACnet Building Controller (B-BC){MSTP}
   b. BACnet Advanced Application Controller (B-AAC){MSTP}
   c. BACnet Application Specific Controller (B-ASC){MSTP}
2. All BACnet Controllers shall use the following communication specifications and achieve performance as specified herein: {MSTP}
   a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU). {MSTP}
      1) Any controller on the MS/TP Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.{MSTP}
   b. Performance{MSTP}
      1) Each BACnet MS/TP controller shall have a minimum of 64Kb of RAM and 384Kb of non-volatile flash memory. {MSTP}
      2) Each controller shall have a 32-bit microprocessor operating at 68 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2008 and the BACnet Device Profile supported. {MSTP}
      3) Each BACnet controller on the BACnet MS/TP communications trunk {MSTP}shall provide a loading characteristic of minimum 1/8th Load.
      4) Manufacturers, who wish to supply LCU and TCU controllers with less than a 32-bit microprocessor and/or a MS/TP loading characteristic of greater than 1/8th Load, may do so as long as they only provide a maximum of 32 controllers on a single bus segment per NCU.{MSTP}
   c. BACnet Controllers shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings. {MSTP}
      1) The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. {MSTP}
   d. Control Unit (LCU) and Terminal Control Unit (TCU) {MSTP}
1) Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications. {MSTP}

2) All control sequences programmed into the LCU and TCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. {MSTP}

3) LCU and TCU controllers that are not fully programmable and/or cannot retain programming as outlined in .2 are not acceptable. {MSTP}

e. BACnet Controllers shall communicate with the Network Control Unit (NCU) via a BACnet/IP connection at a baud rate of not less than 100 Mbps or via the RS485 MS/TP connection at a baud rate of not less than 76.8 kbps. {MSTP}

f. BACnet TCU to have a communications port for connecting a matching room temperature and/or humidity sensor and does not utilize any of the I/O points of the Controller. {MSTP}

1) The TCU and all other devices on the BACnet bus shall be accessible from this communications port. {MSTP}

g. The Contractor supplying the BACnet Controllers shall provide documentation for each device, with the following information at a minimum: {MSTP}

1) BACnet Device; MAC address, name, type and instance number {MSTP}

2) BACnet Objects; name, type and instance number {MSTP}

h. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each BACnet controller, as required by the Point List located in the POINTS LIST section of this specification. {MSTP}

B. Local Control Units (LCU) (Primary Systems such as AHU, MAU, Chiller, Boiler, Water System)

1. The Local Control Units (LCU) shall be 32 bit microprocessor-based.
   a. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.
   b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
   c. The LCU will be supplied with a factory installed integral color operator interface (see 23 09 13 2.6B.8 for details) that provides real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

1) Alternatively a field mounted display and interface, meeting the specified functionality, shall be supplied for each controller in lieu of this requirement.

2. Each LCU shall have sufficient memory, to support its own operating system and databases, including:
   a. Control processes
   b. Energy management applications
   c. Alarm management applications
   d. Historical/trend data for points specified
   e. Maintenance support applications
   f. Custom processes
   g. Manual override monitoring

3. Each LCU shall support:
   a. Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

   1) Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

   2) Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

   3) Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

   4) Digital outputs (contact closure for motor starters up to size 4).

   5) Analog outputs of 4-20 mA and 0-10 Vdc.

4. The LCU analog or universal input shall use a 16 bit A/D converter.
   a. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

5. The LCU analog or universal output shall use a 10 bit D/A converter.
6. Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection.
   a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
   b. As a minimum, provide one of each type of point available on the controller.
7. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
8. The LCU’s factory installed color operator interface will provide real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.
   a. The operator interface shall consist of:
      1) An icon-based, interactive backlit color display.
      2) A turn and select navigation jog dial to access, edit, and modify internal controller functions. The jog dial shall be used to navigate through menus, select options and icons, and change parameters. Scroll buttons (up, down, left and right) shall not be acceptable.
      3) Navigable menus to display, select, edit, and modify values and other controller information.
      4) List-based menus with a minimum of eight (8) lines of text.
      5) Icon-based menus.
      6) A display with the following minimum characteristics: a resolution of 400 W x 240 H pixels with an effective viewing area of 2.4" L x 1.4" H, and 2.8" diagonal viewing area.
   b. The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.
   c. The operator interface shall, at a minimum, have the following functions:
      1) Points. The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, multistate values, Intelligent Space Sensor (ISS) (see section 23 09 13 2.9 Intelligent Space Sensors (ISS)) inputs, and wireless inputs.
         a) The points list menus shall allow the operator to monitor, set, and override controller points and values.
         b) A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.
      2) Alarms. The operator interface shall provide a controller’s alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.
         a) The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.
         b) The combination of an icon and its color state shall notify the operator of an alarm condition.
         c) The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.
      3) Overrides. The operator interface shall provide an overrides menu to view a list of the controller’s overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.
      4) PID loops. The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).
      5) The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.
      6) The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as...
the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.

7) Favorites. The operator interface shall allow access to a list of bookmarked points.

8) Weather. The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.

9) Password protected. The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.

10) Settings. The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.

9. The LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.
   a. The controller shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication.

10. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN OWS or Server.
   a. Controller requiring a local port to reload the controller software is not acceptable.

11. Provide an onboard network communication jack for connection to the BACnet Network (RJ-45 or equivalent quick connect) (MSTP)

12. Wireless port supporting a wireless transceiver for communication with wireless sensors/switches

13. Acceptable Products:
   a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) or BACnet Advanced Application Controller (B-AAC){MSTP}

C. IP Controller (IP-CTRL){BIP}

1. The IP-CTRL shall be 32 bit microprocessor-based operating at a minimum of 1 GHz.
   a. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. {BIP}
   b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list. {BIP}

2. Each IP-CTRL shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases, including:{BIP}
   a. Control processes{BIP}
   b. Energy management applications{BIP}
   c. Alarm management applications{BIP}
   d. Historical/trend data for points specified{BIP}
   e. Maintenance support applications{BIP}
   f. Custom processes{BIP}
   g. Web Based interface via integral Web Server.{BIP}
   h. Support for up to a minimum of 256 I/O points which are added via Expansion I/O modules.{BIP}
   i. Shall have a graphical interface with a common library of HVAC system image and animation such as AHU, MAU, Boiler Plant, Chiller Plant, and Rooftop Unit.{BIP}

3. The IP-CTRL shall have a Real Time clock.{BIP}

4. The IP-CTRL will support the following communications protocols:{BIP}
   a. BACnet/IP{BIP}
      1) Supporting both IPv4 and IPv6.{BIP}
      2) DHCP support and Auto DNS.{BIP}
      3) 2 - RJ45 ports each capable of supporting 10/100 Base-T.{BIP}
a) Supporting controller daisy chaining on the Ethernet network via integral router functionality.{BIP}

4) If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.{BIP}

b. BACnet MS/TP supporting up to minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.{BIP}
   1) Supporting 9600 to 115200 baud{BIP}

c. Modbus RTU{BIP}
   1) Supporting 9600 to 115200 baud{BIP}

d. 2 x USB 2.0 Expansion ports:{BIP}
   1) 802.11 Wi-Fi Adapter for:{BIP}
      a) Mesh Network technology.{BIP}
      b) Local Inter/intranet ‘Hot Spot’ connectivity{BIP}
      c) Wireless Ethernet.{BIP}
   2) EnOcean receiver for Wireless sensors{BIP}
   3) If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.{BIP}

5. Acceptable Products:{BIP}
   a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) {BIP}with outlined enhanced features.

D. IP-CTRL MS/TP Expansion modules:{BIP}
   1. BACnet MS/TP supporting up to a minimum 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.{BIP}
      a. Supporting 9600 to 115200 baud{BIP}

E. IP-CTRL Expansion I/O modules:{BIP}
   1. Each IP-CTRL Expansion I/O module shall be capable of monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:{BIP}
      a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.{BIP}
      b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.{BIP}
         1) The analog or universal input shall use a 16 bit A/D converter.{BIP}
            a) Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.{BIP}
   2. Each IP-CTRL Expansion I/O module shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:{BIP}
      a. Digital outputs.{BIP}
         1) Optional Form C relay outputs.{BIP}
      b. Analog outputs of 4-20 mA and 0-10 Vdc.{BIP}
         1) The analog or universal output shall use a 10 bit D/A converter. {BIP}
      c. HOA (Hand, Off, Auto) support.{BIP}
   3. Each completed configuration of IP-CTRL and Expansion I/O modules shall have a minimum of 10% spare capacity for each point type for future point connection. {BIP}
      a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. {BIP}
      b. As a minimum, provide one of each type of point available on the controller.{BIP}
   4. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.{BIP}

F. IP VAV Controller (IP-VAV){BIP}
   1. Refer to 23 09 13 Variable Air Volume (VAV) Terminal Control Units (TCU) for VAV related functionality requirements.{BIP}
      a. In cases of conflict between this section (IP-VAV) and the referenced section (VAV) this section (IP-VAV) takes precedence.{BIP}
2. The IP-VAV shall be 32 bit microprocessor-based operating at a minimum of 400 MHz. (BIP)
   a. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. (BIP)
   b. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list. (BIP)

3. Each IP-VAV shall have minimum of 512MB memory, with a minimum of 1GB non-volatile flash, to support its own operating system and databases, including:{BIP}
   a. Control processes (BIP)
   b. Maintenance support applications (BIP)
   c. Custom processes (BIP)

4. The IP-VAV shall have a Real Time clock with rechargeable battery. (BIP)

5. Power Requirements (BIP)
   a. 24 VAC with local transformer power (BIP)
   b. 50 VAC utilizing Power Over Ethernet (POE) (BIP)

6. The IP-VAV will support the following communications protocols:{BIP}
   a. BACnet/IP (BIP)
      1) Supporting both IPv4 and IPv6 (BIP)
      2) DHCP support and Auto DNS (BIP)
      3) 2 - RJ45 ports each capable of supporting 10/100 Base-T. (BIP)
         a) Supporting controller daisy chaining on the Ethernet network via integral router functionality. (BIP)
         b) Power Over Ethernet (POE) capable (BIP)
      4) If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality. (BIP)
   b. 2 x USB 2.0 Expansion ports for:{BIP}
      1) Wi-Fi Adapter for Ethernet connectivity (BIP)
      2) EnOcean receiver for Wireless sensors (BIP)
      3) If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality. (BIP)

7. Acceptable Products:{BIP}
   a. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) (BIP)

G. Variable Air Volume (VAV) Terminal Control Units (TCU)
   1. The VAV TCU controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.
   2. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.
   3. The controllers shall also function normally under ambient conditions of 32 °F to 122 °F and 5% to 90% RH (non-condensing). (USC)
   4. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
   5. The VAV TCU shall include a built-in ‘flow thru’ differential pressure transducer.
      a. The controller shall convert this value to actual air flow.
      b. Single point differential pressure sensing device is not acceptable.
      c. Membrane based pressure differential transducer is not acceptable.
      d. The VAV TCU differential pressure transducer shall have a measurement range of 0 to 2 in. W.C. and measurement accuracy of ±4% at 0.05 to 2 in. W.C. and a minimum resolution of 0.0001 in. W.C., insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified minimum and maximum air flow parameters. (USC)
      e. VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable.
   6. The BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.
7. The VAV TCU shall include provision for air flow balancing using a local air flow balancing interface.
8. An Intelligent Space Sensor (ISS) (see section 23 09 13 2.9 Intelligent Space Sensors (ISS)) shall be used for balancing air flow.
   a. In lieu of an ISS, a portable air flow balancing interface capable of balancing air flow is acceptable.
9. The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.
10. The VAV TCU shall also provide an air flow balancing tool.
11. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.
12. Systems not able to provide a web based air balance tool or a portable air flow balancing interface or an Intelligent Space Sensor (ISS) (see section 23 09 13 2.9 Intelligent Space Sensors (ISS)) capable of balancing air flow as part of the VAV TCU controller shall provide an individual full time technician during the air flow balancing process to assure full balance compliance.
13. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5 °F of setpoint at the room sensor location. {USC}
14. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements.
   a. This algorithm shall function to signal the respective controller to perform the required discharge temperature reset in order to maintain space temperature setpoint.
15. It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.

2.7 LOCAL DISPLAY UNIT (LDU)

A. A wall mounted easy to operate User Interface that provides direct read / write access to any point on the network.

B. The LCD Display shall provide the following:
   1. The Display shall consist of an alphanumeric LCD display of 16 lines x 16 characters, and a multi-function keyboard. At total of 250 points shall be available for display and or control in groups of 50.
      a. Each group shall have a minimum of a 13 character alphanumeric descriptor and each point shall have up to a minimum of a 16 character alphanumeric descriptor.
   2. The display shall have a graphical logo displayed on its default screen. This logo shall be a standard monochrome bitmap of 89 x 128 pixels that the user can replace.
      a. Configuration of the display shall be made available from a wizard contained within the system programming tools.
   3. The Display User access shall be through a simple to use directional and entry buttons. Full keyboards shall be accepted.

C. The LCD Display shall be provided as a surface mount or flush mount as shown on the mechanical drawings.

2.8 MOBILE APPLICATION FOR ANDROID\(^1\) AND IOS\(^2\) PLATFORMS

A. The application for mobile platforms shall provide real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

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1 an open source operating system by Google, based on the Linux kernel.
2 Is a mobile operating system developed by, and a registered mark of, Apple Inc.
1. The operator interface consists of:
   a. An icon-based, interactive application for Android and iOS devices.
   b. Standard Android and iOS navigation methods shall be used to access, edit, and modify internal controller functions and shall be used to navigate through menus, select options and icons, and change parameters.
   c. Navigable menus to display, select, edit, and modify values and other controller information.
   d. List-based menus.
   e. Icon-based menus.

2. The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.

3. The operator interface shall, at a minimum, have the following functions:
   a. Points. The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, multistate values, Intelligent Space Sensor (ISS) (see section 23 09 13 2.9 Intelligent Space Sensors (ISS)) inputs, and wireless inputs.
      1) The points lists menus shall allow the operator to monitor, set, and override controller points and values.
      2) A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.
   b. Alarms. The operator interface shall provide a controller’s alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.
      1) The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.
      2) The combination of an icon and its color state shall notify the operator of an alarm condition.
      3) The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.
   c. Overrides. The operator interface shall provide an overrides menu to view a list of the controller’s overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.
   d. PID loops. The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).
   e. The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.
   f. The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.
   g. Favorites. The operator interface shall allow access to a list of bookmarked points.
   h. Weather. The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.
   i. Password protected. The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.
   j. Settings. The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.
2.9 INTELLIGENT SPACE SENSORS (ISS)

A. Intelligent Space Sensors (ISS) shall communicate on a daisy-chained network connected to any Local Control Unit (LCU) or Terminal Control Unit (TCU) and shall provide ambient space condition sensing without the use of hardware I/O at the LCU or TCU.

B. Each ISS shall provide a white Liquid Crystal Display (LCD), where indicated on the drawings, with the following minimum features:
   1. Minimum 1.4" x 1.18" display area (USC)
   2. Backlit

C. The ISS shall be capable of displaying on its LCD the measured space temperature from 50 °F to 104 °F and/or humidity from 0 % RH to 100 % RH with one decimal and/or the CO2 measurement from 0 to 2000 ppm. (USC)

D. The ISS with motion sensor shall have a motion indicator LED that provides a visual confirmation whenever motion is detected. A feature used to enable or disable this motion indicator shall be provided.

E. The ISS shall be capable of displaying the following elements:
   1. Space temperature
   2. Cooling space temperature set point
   3. Heating space temperature set point
   4. Current heating or cooling mode
   5. Current occupancy mode
   6. Fan speed
   7. Light status
   8. Blind position
   9. Alarm condition
   10. Current time
   11. Energy consumption indicator

F. Each ISS shall provide a local keypad for local user interface to perform navigation and adjustment of points configured as adjustable.

G. The ISS shall be configured for the LCU or TCU intended application requirements.

H. Provide an ISS where indicated on the drawings each ISS shall provide at a minimum the following on-board integral I/O without the consumption of any inputs and/or outputs at the host LCU or TCU:
   1. Temperature Sensor
      a. Sensing Element: 10k Thermistor
      b. Accuracy: ±0.9 °F (USC)
      c. Resolution: ±0.18 °F (USC)
      d. Range: 41 °F to 104 °F (USC)
   2. Relative Humidity Sensor
      a. Accuracy: ±3 % RH
      b. Resolution: 1 % RH
      c. Range: 10 % RH to 90 % RH
   3. CO2 Sensor
      a. Accuracy: 400 to 1,250 ppm ± 30 ppm or 3% of reading, 1,250 to 2,000 ppm ± 5% of reading ± 30 ppm
      b. Range: 0 to 2,000 ppm
      c. Operating elevation: 0 to 16,000 ft (USC)
      d. Calibration method: self-calibration method eliminates the need for manual calibration and calibrates the sensor based on baseline concentrations measured...
during unoccupied periods in the space. Sensor shall not require manual calibration over a minimum product rated life of 15 years.

e. Temperature dependence: 0.11% FS per °F\{USC\}

f. Stability: <2% of FS over life of sensor (15 years)

g. Pressure dependence: 0.135% of reading per mm Hg

h. Sensing method: Non-dispersive infrared (NDIR) absorption and Gold plated optics shall be provided.

4. Motion Sensor
   a. Type: Passive Infrared (PIR) sensor with Fresnel lens
   b. Vertical detection range: up to 20 ft. x 30 degree detection angle\{USC\}
   c. Horizontal detection range: up to 20 ft. x 120 degree detection angle \{USC\}

I. The ISS shall provide function to fully balance the air flow of a Variable Air Volume (VAV) Terminal Control Unit (TCU).
   1. The ISS shall allow the air balancer to control the action of the VAV TCU including the following function: open VAV damper, close VAV damper, go to flow setpoint.
   2. The ISS shall allow the air balancer to enter flow related parameters including minimum air flow, maximum air flow and K factor.
   3. The ISS shall be capable of operating as a handheld tool for air balancing functions in situations where the ISS is not required as an installed sensor.

J. The ISS menus provide function to configure the Terminal Control Unit (TCU) shall define items such as I/O configurations, set point and delays.

K. The configuration tool or through an Intelligent Space Sensor (ISS) menus shall allow to commission the TCU application and perform action such as inputs calibration, outputs override.

L. The ISS shall provide password protected menus or any other mechanism to prevent a local user to access advanced configuration menus including air flow balancing menu and network addressing.

M. Programmable to display up to ninety six (96) data points in any combination of local and/or networked values from any device on the internetwork.

N. Each ISS shall provide a point of access for a Service Tool, Supervisory Tool, etc. to the internetwork via the ISS communication port.

O. The ISS shall be capable of promoting good energy usage practices to the room occupant by displaying an Energy Consumption Indicator (ECI).
   1. The ECI shall be modified in real-time when the room occupant modifies a parameter of the Local Control Unit (LCU) or Terminal Controller Unit (TCU) such as the room temperature setpoint or the fan speed.
   2. The ECI shall indicate to the room occupant the energy impact of the parameter changes via a 5 level display icon where a full display (5th level) indicates excellent energy conservation and no display indicating no energy conservation.
   3. The ECI follows the algorithm for energy efficiency as outlined in ASHRAE 55-2004.
   4. If ECI is not available then:
      a. A stainless steel plate with 4 LEDs must be mounted adjacent to the thermostat.
      b. The plate is to be engraved, adjacent to each LED, with symbology which will encourage the occupant to conserve energy.
      c. ECI level (0 to 4) is to be indicated via digital outputs driving the LEDs.
      d. Algorithm to be used; as defined in ASHRAE 55-2004

PART 3 - EXECUTION

3.1 MANUFACTURER'S RECOMMENDATIONS

A. Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.
3.2 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.3 FIELD QUALITY CONTROL

A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Continually monitor field installation for code compliance and workmanship quality.

C. Contractor shall arrange for work inspection by authorities having jurisdiction over the work.

3.4 WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer’s recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC

C. Low-voltage wiring shall meet NEC Class 2 requirements. Sub fuse low-voltage power circuits as required to meet Class 2 current limit.

D. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

E. Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10 ft. intervals{USC}

I. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.
J. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

K. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

L. Include one pull string in each raceway 1 in. or larger.{USC}

M. Use color-coded conductors throughout.

N. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

O. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 in. between raceway and high-temperature equipment such as steam pipes or flues.{USC}

P. Adhere to requirements in Division 16 where raceway crosses building expansion joints.

Q. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

R. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

S. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.{USC}

T. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.5 COMMUNICATIONS WIRING

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

G. Runs that are longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

H. Label communication wiring to indicate origination and destination.
I. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.6 FIBER OPTIC CABLE

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

C. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

D. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

END OF SECTION
SECTION 23 09 13.13

BAS ACTUATORS AND OPERATORS

PART 1 - GENERAL

1.1 RELATED SECTIONS

A. SECTION 23 09 00, BAS Instrumentation and Control
B. SECTION 23 09 13, BAS Instrumentation and Control Devices
C. SECTION 23 09 13.23, BAS Sensors and Transmitters
D. SECTION 23 09 13.43, BAS Control Dampers
E. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES

A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 ACTUATORS

A. For dampers, the actuators used shall be provided from a single manufacturer
B. For valves, the actuators used shall be provided from a single manufacturer
C. Actuators shall be provided from a manufacturer registered under ISO9001:2000.
D. Electronic Damper Actuators.
   1. Size for torque required for damper seal at load conditions.
   2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
   3. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
   4. Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.
   5. Fail-Safe Operation: Mechanical, spring-return mechanism. Internal chemical storage systems, capacitors, or other internal non-mechanical forms of fail-safe operation are not acceptable.
   6. Power Requirements (Two-Position Spring Return): 24 or 120 VAC as required.
   7. Power Requirements (Proportional): Maximum 10 VA at 24 VAC or 8 W at 24 VDC.
   8. Temperature Rating: -22 to +122°F (-30 to +50°C)
   10. Agency Listing: ISO 9001, UL, UL(C) and CSA C22.2 No. 24-93.
E. Terminal Unit Actuators
2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle or an ISO-style direct-coupled mounting pad.
3. Power Requirements: Maximum 1 VA at 24 VAC or 1 W at 24 VDC.
4. Temperature Rating: -22 to +122°F (-30 to +50°C). Housing Rating: Minimum UL94-5V(B) flammability.
5. Agency Listing: CE, UL 60730-1A/-2-14, CAN/CSA E60730-1, CSA C22.2 No. 24-93, CE according to 89/336/EEC.

PART 3 - EXECUTION

3.1 ACTUATORS

A. General: Mount actuators and adapters according to manufacturer's recommendations.

B. Electric and Electronic Damper Actuators.
   1. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.
   2. Link actuators according to manufacturer's recommendations.
   3. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
   4. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately the 5° open position, manually close the damper, and then tighten linkage.
   5. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   6. Provide necessary mounting hardware and linkages for actuator installation.

END OF SECTION
SECTION 23 09 13.23
BAS SENSORS AND TRANSMITTERS

PART 1 - GENERAL

1.1 RELATED SECTIONS
A. SECTION 23 09 00, BAS Instrumentation and Control
B. SECTION 23 09 13, BAS Instrumentation and Control Devices
C. SECTION 23 09 13.13, BAS Sensors and Transmitters BAS Actuators and Operators
D. SECTION 23 09 13.43, BAS Control Dampers
E. SECTION 23 09 23, BAS Direct Digital Control System

1.2 REFERENCES
A. Refer to Section 23 09 00 - References

1.3 ACRONYMS, ABBREVIATIONS AND DEFINITIONS
A. Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 SENSORS AND DEVICES
A. Input/output sensors and devices shall be closely matched to the requirements of the BAS controller for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

B. Sensors and transmitters shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.

C. Provide guards (plastic or wire) for sensors, thermostats, and transmitters that are installed in public areas such as gymnasiums, classrooms, corridors, and vestibules.

D. Temperature sensors shall have the following characteristics:
   1. Sensors shall have +/- 1.0 °F accuracy between 32 °F and 212 °F.
   2. Space temperature sensors
      a. Shall consist of an element within a ventilated cover.
      b. Space sensors located in mechanical rooms and public shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment).
      c. Space sensors shall be provided in accordance with the drawings and specifications with the following options:
         1) Sensor complete with Network Jack
         2) Sensor complete with Network Jack, and Set Point Adjustment
         3) Sensor complete with Network Jack, and illuminated Override switch
         4) Sensor complete with Network Jack, Set Point Adjustment, and illuminated Override switch
5) Sensor complete with Network Jack, Set Point Adjustment, illuminated Override switch and Fan Speed Selection.

E. RTD Transmitter
1. Where reference is made on the drawings for a RTD transmitter, it shall be interpreted as follows:
2. Transmitters shall meet at minimum the following requirements.
   a. Provide an RTD transmitter in configurations below meeting the following requirements:
      1) 100 ohm or 1000 ohm PT RTD
      2) 24V ac/dc power supply.
      3) 4-20 mA, 0-10Vdc or 0-5Vdc outputs compatible with BMS.
      4) Electronics accuracy of +/-0.1% of span.
      5) Operating temperature range of 32˚F to 158˚F. OSA only - operating temperature range of -40˚F to 185˚F.{USC}
   6) Optional LCD display

F. Temperature Sensor – Outside Air
1. Provide outside air temperature sensors as indicated within the field termination schedules and/or controls diagrams.
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. Aluminum LB with PVC sun and windscreen.
   b. Wall mount weatherproof enclosure with conduit entrance.
   c. Thermistor or RTD compatible with BMS

G. Temperature Sensor – Duct Mounted – Single Point
1. Provide duct mounted, single point, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows:
   a. In ducts less than 10 ft² in cross-sectional area.{USC}
   b. In ducts greater than 10 ft² in cross-sectional area if there is no heating coil and no cooling coil and no mixing of air flows of different temperature upstream.{USC}
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. 0.25" stainless steel probe of length between one-third and two-thirds of the duct width.{USC}
   b. Thermistor or RTD compatible with BMS, sealed in probe with 3 part moisture protection system.
   c. Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal, weather proof or no enclosure available)

H. Temperature Sensor-Wall Mounted
1. Provide wall mounted temperature sensors for non-public spaces as indicated within the field termination schedules and/or controls diagrams as follows.
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. White protective enclosure.
   b. The location to be selected by the Engineer/Architect at a height of 5 feet. No sensor shall be mounted until the Engineer/Architect gives specific location instructions.{USC}
   c. Thermistor or RTD compatible with BMS.
   d. Optional set point adjustment, push button override switch, LED indication, bi-metal, alcohol or LCD display depended on owner requirement.

I. Temperature Sensor-Wall Mounted-Microprocessor Based
1. Provide wall mounted temperature sensors for non-public spaces as indicated within the field termination schedules and/or controls diagrams as follows.
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. White protective enclosure.
b. The location to be selected by the Engineer/Architect at a height of 5 feet. No sensor shall be mounted until the Engineer/Architect gives specific location instructions.

c. Thermistor or RTD compatible with BMS.

d. 3.5 digit LCD display of room temperature and set-point

e. Push button set-point adjustment-resistance or analog

f. Optional override switch

g. Optional LED

J. Temperature Sensor – Wall Mounted – Lobby, Hallways Or Security Spaces
1. Provide wall mounted stainless plate temperature sensors for lobbies and lobby vestibule spaces as indicated within the field termination schedules and/or control diagrams as follows.
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. Stainless plate sensors to fit 100 x 50mm (4"X2") junction box, available with or without tamperproof screws.
   b. Thermistor or RTD compatible with BMS.

K. Temperature Sensor – Immersion - Thermo well Mounted
1. Provide thermo well mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams as follows.
2. Temperature sensors shall meet, at minimum, the following requirements:
   a. Rigid 0.25” stainless steel probe of length, which is, at minimum, 20% of the pipe width.
   b. Thermistor or RTD Compatible with BMS sealed in probe with three-part moisture protection system.
   c. BMS shall report the monitored temperature with an accuracy of 0.5˚C (1.0˚F).
   d. ABS housing with conduit entrance. (Optional metal or weather proof available)
   e. Provide Brass or Stainless steel thermo well (316 or 304).
   f. Provide with thermal grease to aid temperature sensing.

L. Temperature Sensor – Strap-On
1. Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:
   a. 0.25" Stainless steel probe, 2’
   b. Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system
   c. ABS housing with conduit entrance. (Optional metal or weather proof available)

M. Temperature Sensor – Strap-On - Plate
1. Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:
   a. Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system
   b. A single point strap-on temperature sensor to be precision bonded to a 1.5”x1.5” aluminum plate and adhered to a 1.5” x 1”compressible foam. A 10” S/S Pipe clamp to be provided to secure the assembly to various sizes of pipe.
   c. ABS housing with conduit entrance. (Optional metal or weather proof available)

N. Relative Humidity Sensor – Wall Mounted
1. Provide wall mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:
   a. White protective enclosure
   b. Sensor to be laser trimmed thermoset polymer based capacitive type.
c. 24 Vac/dc power supply

d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

e. 2% accurate (5-95% RH). (3 & 5 % accurate units available)

f. Operating temperature range of 32˚F to 158˚F.{USC}

g. Reverse voltage protected and output limited.

h. Optional LCD display-SP and RH100A series

i. Optional set point adjustment-SP series

j. Optional push button override-RH100A series

O. Relative Humidity Sensor – Duct Mounted

1. Provide duct mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Duct mounted relative humidity sensors shall meet, at minimum, the following requirements:
   a. ABS housing with conduit entrance.
   b. Sensor to be laser trimmed thermoset polymer based capacitive type.
   c. 24 Vac/dc power supply.
   d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.
   e. 2% accurate (5-95% RH). (3 & 5 % accurate units available)
   f. 230mm (9”) probe length.
   g. Operating temperature range of 32˚F to 158˚F.{USC}
   h. Reverse voltage protected and output limited.

P. Relative Humidity Sensor – Outside Air

1. Provide OSA relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:
   a. ABS hinged weatherproof housing with conduit entrance.
   b. Sensor to be laser trimmed thermoset polymer based capacitive type.
   c. 24 Vac/dc power supply.
   d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.
   e. 2% accurate (5-95% RH).
   f. Operating temperature range of 32˚F to 185˚F.{USC}
   g. Reverse voltage protected and output limited.

Q. Combination Relative Humidity And Temperature Sensors

1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.

R. Static Pressure Sensor – Duct Mounted

1. Provide duct mounted static pressure sensors as indicated within the Field termination schedules and/or control diagrams. Static pressure sensors shall meet, at minimum, the following requirements:
   a. Input range shall be appropriate for the application. Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior. Typically, for low pressure commercial duct consider using a range of 0 to 2” wc., for medium pressure duct use a range of 0 to 6” wc. and for high-pressure duct use a range of 0 to 10” wc.{USC}
   b. 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.
c. 1% Full scale output accuracy
d. Operating temperature range of 32˚F to 140˚F.{USC}
e. Easily accessible, integral non-interacting zero adjustment.
f. Minimum over pressure input protection of two times rated input or 20 psi whichever is greater.{USC}

S. Room Pressure Sensor
1. Provide space static pressure sensors as indicated within the Field termination schedules and/or control diagrams. Static pressure sensors shall meet, at minimum, the following requirements:
   a. Input range of -0.2" to + 0.2" wc. {USC}
   b. 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.
   c. 1% accuracy of range
   d. Operating temperature range of 0˚C to 60˚C.
   e. Operating temperature range of 32˚F to 140˚F.
   f. Easily accessible, integral non-interacting zero adjustment.
   g. Minimum over pressure input protection of two times rated input or 20 psi whichever is greater.{USC}

T. Differential Pressure Sensor – Air (Filter/Coil Monitoring)
1. Provide air differential pressure sensors as indicated in field termination schedules and/or control diagrams. Air differential pressure sensor shall meet, at minimum, the following requirements:
   a. Sensors used for filter or coil differential pressures shall also have a display of the monitored differential pressure.
   b. Output shall be 4-20mA, 0-10Vdc or 0-5Vdc output proportional to pressure input range compatible with BMS.
   c. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0-2" wc range for low-pressure commercial duct. {USC}
   d. Operating temperature range of 32˚F to 140˚F.{USC}

U. Differential Pressure Switch – Air
1. Provide air differential pressure switches as indicated in field termination schedules and/or control diagrams. Air differential pressure switches shall meet, at minimum, the following requirements:
   a. An IP54 (NEMA 13) polycarbonate housing.
   b. SPDT switch rated at 250 Vac at 1 amp.
   c. Field adjustable range from 0.02" wc to max range of device. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2" wc range for low-pressure commercial duct. {USC}
   d. Temperature range of -4˚F to 140˚F.{USC}
   e. Set point adjustment knob with indication.
   f. Automatic reset.

V. Air Flow Sensor
1. Provide airflow rate sensors and transducers as indicated in the Field termination schedules and/or control diagrams. Air flow rate sensors and transducer shall meet, at minimum, the following requirements:
   a. Hot wire anemometer type.
   b. Self-compensation for changes in air temperature.
   c. Probe and transducer housing shall be constructed of durable PVC.
   d. Probe shall be adjustable from 2" - 7.3". {USC}
   e. Power supply shall be 24 Vac/dc.
   f. Output signal of 4-20 mA or 0-10Vdc proportional to air flow speed equal to 3150 ft/min or 1575 ft/min jumper selectable. {USC}
   g. Air temperature range of 14˚F to 140˚F. {USC}
Trinity Valley Community College  
BAS SENSORS AND TRANSMITTERS  
Health Science Center  
50% CD’S / GMP Pricing  
RSA Project No. 1707.00  
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December 29, 2017

h. 5% accuracy of measured value.

W. Water Pressure Sensor
1. Provide water pressure sensors as indicated within the Field termination schedules and/or control diagrams. Pressure sensors shall meet the following requirements:
   a. Operating range shall be suitable for the application. Select range such that it covers from zero pressure to twice the amount of pressure desired for control purposes or that could be encountered.
   b. 4-20 mA output proportional to water pressure.
   c. 0.25% accuracy of range.
   d. Temperature range of -40˚F to 260˚F.{USC}
   e. Over pressure input protection of a minimum two times rated input.
   f. An optional ABS wiring housing is available for an interior application and weatherproof wiring housing is available for an exterior application.
   g. 17-4PH stainless steel wetted parts.
   h. Burst pressure of a minimum five times rated input.

X. Water Differential/Gage Pressure Sensor
1. Provide water differential or gage pressure sensors as indicated in the Field termination schedules and/or control diagrams. Water differential pressure sensors shall meet, at minimum, the following requirements:
   a. Output of 4-20 mA, 0-10 or 0-5 Vdc proportional to the pressure sensed.
   b. Momentary over pressure protection of five times the rated input.
   c. Operating range shall be suitable for the application. Select range such that it covers from zero differential pressure up to a differential static pressure of 20% to 50% in excess of the maximum static pressure that could be encountered. Remember that if the sensor is used for the control of a chilled water bypass and is located across, for example, a chilled water AHU coil, the pressure drop of both the coil and the associated valve at full design flow have to be taken into account.
   d. Accuracy of better than 1% of full-scale reading.
   e. Valve tapping shall be furnished and installed by the Mechanical contractor. Coordinate with the Mechanical contractor.

Y. Current Relay/Switch
1. Provide current sensing relays as indicated in the Field termination schedules and/or control diagrams. Current sensing relays shall meet, at minimum, the following specifications:
   a. Rated for the applicable load.
   b. The output relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.
   c. Current relay shall have input and output isolation via current transformer.
   d. Current relay shall be self-powered with no insertion loss.
   e. Relay shall be in a dustproof housing.
   f. Accuracy to be <2% of full-scale max.
   g. Temperature rating of 5˚F to 140˚F.{USC}
   h. Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay.
   i. The BMS contractor shall provide current sensing relays at the MCC starters.
   j. The BMS contractor shall provide the current sensing relays for motors with local starters and no MCC starter.

Z. Current Sensor
1. Provide monitoring of the current as identified in Field termination sheets and/or control drawings. Current monitoring shall meet, at minimum, the following requirements:
   a. 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw.
   b. Reverse polarity protected and output limited.
   c. 50/60 Hz operation.
d. Accuracy of better than 1%.
e. Operating temperature range of -20˚F to 120˚F. {USC}

AA. Electronic To Pneumatic Transducers
1. Provide electronic to pneumatic transducers as identified in the field termination sheets and/or controls drawings. Transducers shall include, at minimum, the following:
   a. Accept a control signal of 4-20mA or 0-10Vdc compatible with BMS.
   b. Output rating of 3-15psig consuming 515 scfm maximum @ 20 psig supply. {USC}
   c. Snap track mounted for panel applications or with an optional ABS enclosure.
   d. Operating temperature range of 32˚F to 140F. {USC}
   e. Male barb fittings for flexible tubing.

BB. Air Quality Sensor - Wall Mounted
1. Provide wall mounted air quality sensors as indicated within the Field termination schedules and/or control diagrams. Sensors shall meet, at minimum, the following requirements:
   a. Measurement of volatile organic compounds (VOC) that could contain, at minimum, the following gases:
      1) Methane
      2) Ethylene
      3) Hydrogen
      4) Carbon Monoxide
      5) Propane
      6) Ammonia
   b. Microprocessor based using a semiconductor element based on the Taguchi gas principle.
   c. White attractive ventilated cover.
   d. 20-30 Vac/dc power supply, 100mA @24Vdc, 220mA @24Vac, 6VA max.
   e. Analog stepped output standard 0-10 Vdc or optional 4-20mA and adjustable relay.
   f. Programming and selection via internal push buttons and jumpers.
   g. Temperature range of 32˚F to 104˚F. {USC}

CC. Air Quality Sensor - Duct Mounted
1. Provide duct mounted air quality sensors as indicated within the field termination schedules and/or control diagrams. Sensors shall meet, at minimum, the following requirements:
   a. Measurement of air stream volatile organic compounds (VOC) that could contain, at minimum, the following gases:
      1) Methane
      2) Ethylene
      3) Hydrogen
      4) Carbon Monoxide
      5) Propane
      6) Ammonia
   b. Microprocessor based using a semiconductor element based on the Taguchi gas principle.
   c. 20-30 Vac/dc power supply, 100mA @24Vdc, 220mA @24Vac, 6VA max.
   d. Analog stepped output standard 0-10 Vdc or optional 4-20mA and adjustable relay.
   e. Programming and selection via internal push buttons and jumpers.
   f. Temperature range of 32˚F to 104˚F. {USC}
   g. 8” duct probe. {USC}

DD. Carbon Dioxide (CO2) Sensor
1. Provide a space or duct carbon dioxide gas detection sensor as indicated within the field termination schedules and/or control diagrams. Carbon dioxide detection sensors shall meet, at minimum, the following requirements:
   a. Set-up to be fully microprocessor based c/w LCD.
b. 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to 0 to 2000 ppm of carbon dioxide concentration
c. Power supply to be 20-28Vac/dc @ 140 mA max for 24 Vac and 80 mA avg. @24 Vdc.
d. No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing the Automatic Calibration Logic Program (ACLP).
e. Standard accuracy to be 3% of reading or 75 ppm, whichever is greater.
f. Optional integral humidity and temperature transmitter or temperature sensor (thermistor or RTD)
g. BACnet communications(MSTP)
h. Optional setpoint adjustment, override switch and relay.
i. Operating temperature of 32˚F to 122˚F.{USC}

EE. Carbon Monoxide (CO) Sensor
1. Provide CO monitoring systems for the enclosed levels of the parking garage. Provide complete coverage of the enclosed levels of the parking garage and provide systems for each level. A CO monitoring system shall not cover an area on more than one level and the failure of any component shall not affect more than one level.
   a. Sensors shall be of the electrochemical type.
   b. Locate sensing points on walls and columns at 5-6ft above floor level. Locate one sensing point per 7500 ft². Do not locate sensing points closer than 6ft to traffic lanes.{USC}
   c. Sensor range shall be of 0 to 300 ppm for 5% accuracy cell
   d. Provide two (2) relay contacts, at minimum, per sensor, to indicate CO warning level (initially set at 50ppm) and CO alarm level (initially set at 200ppm) for each sensing point.
   e. Unit shall be complete with 85 db audible alarm and have visual output reading via an LCD display of the gas sensed.
   f. Provide 4-20mA, 0-10 or 0-5Vdc output of Carbon Monoxide sensed compatible with BAS system.
   g. The proposed sensor locations shall be submitted at the shop drawing stage and shall be amended as directed by the Owner and/or Engineer.
   h. Sensor shall be factory calibrated and will only require calibration after a minimum one (1) year service.

FF. Leak Detection Monitoring – Water
1. Provide water leak monitoring as identified within the Field termination schedules and/or control diagrams. Water leak detection monitors shall meet, at minimum, the following requirements:
   a. Corrosion and abrasion resistant.
   b. Adjustable height-single point model
   c. Configured for normally open or normally closed as required by the application.
   d. Form C output relay rated at 5 amps @ 120 Vac / 30 Vdc.
   e. Operating temperature range of -40˚F to 185˚F.{USC}
   f. Optional remote mount probe and water sensing cable available in different lengths.

GG. Ambient Light Level Sensor
1. Provide ambient light level sensors as indicated within the field termination schedules and/or control diagrams. Light level sensor shall meet, at minimum, the following requirements:
   a. Light sensor shall have a 12 – 35 Vdc power at maximum 22mA current draw.
   b. 4-20 mA output proportional to the ambient light level where 4 mA is light and 20 mA is dark.
   c. Photo sensitive resistor with analog transducer.
   d. Mounted on the exterior of a North wall on the roof.
2.2 WIRELESS SENSORS

A. Provide for wireless sensing of the designated sensors and or switches as shown on the Point List Chart. {WIRELESS}

B. Wireless sensors shall be able to operate at a designated frequency of 315 MHz or 868 MHz, to be determined local regulation. {WIRELESS}

C. Controllers shall be field upgradable to receive wireless communications from switches and sensors (become wireless-enabled) by connecting a plug-in wireless transceiver. {WIRELESS}

D. Sensor data shall be made available on the network to control HVAC and non-HVAC applications such as lighting. {WIRELESS}

E. Wireless sensing is comprised of the following components; wireless sensor or switch (transmitter), wireless receiver, wireless configuration application and wireless transmission test equipment. All components shall comply with these requirements. {WIRELESS}

1. Wireless temperature sensor/switch – the wireless sensing technology provided shall transmit a RF message indicating the value or position of the sensor. The transmission range shall be a minimum of 100 meters unobstructed line of sight and 100 feet in buildings. {WIRELESS}

2. Each sensor or switch shall be provided with energy harvesting technology such that no battery will be required to maintain normal operations. If using a Solar Cell for energy harvesting, normal operation parameters shall be defined as a minimum of 4 hours of 200lx of light to produce an operation of the sensor for a period of no less than 20 hours in total darkness. In sufficient light levels are not available, provide a battery backup. {WIRELESS}

3. For temperature sensors all measurement of value shall be read by the sensor no less than once every 100 seconds and transmit a signal to the receiver within this time period should a variations occur from set point of more than ±1.0 °F for a space sensor or an outside air or duct or water sensor. {WIRELESS}

4. Sensor or switch shall be provided with a unique identifying code to correspond its location to the receiver. The identifying code shall be displayed in bar code permanently attached to the sensor or switch. In addition the sensor or switch shall be provided with a manual push button to transmit its identifying code to the receiver for installation. {WIRELESS}

5. All sensor locations shall be verified to be in compliance with manufacturer’s installation requirements and be tested for acceptable signal strength. {WIRELESS}

6. Wireless sensors and switches shall be provided for the following as required: {WIRELESS}

   a. Space Sensors – Space sensors shall be provided as required with temperature measurement, set point adjustment, override and humidity sensing. Accuracy of the sensors shall be 1.0 °F (0.5 °C). Sensor shall be submitted for pre-approval for performance and visual appearance. {WIRELESS}

   b. Mechanical Room Sensors – Duct temperature sensor, outside air sensor, Surface temperature contact temperature sensor and Well emersion sensor. {WIRELESS}

   c. Light Switches – Light switches shall be provided as required, either in a 2 channels or 4 channels configurations. {WIRELESS}

7. For Local Control Unit (LCU), provide for a minimum of 14 wireless sensor or switches inputs. {WIRELESS}

8. For Terminal Control Unit (TCU) provide for the management a minimum of 5 wireless sensors or switches inputs. {WIRELESS}

9. Wireless Configuration: The configuration of the wireless sensors shall be an integral part of the LCU or TCU programming or configuration tool. {WIRELESS}

10. Wireless Transmission Test Equipment. {WIRELESS}
a. Provide for test equipment that will measure the strength of the transmission between the required location of the sensor or switch and the receiver located at the Controller. {WIRELESS}

b. All Sensors or switches shall be verified to have acceptable signal strength prior to installation.{WIRELESS}

PART 3 - EXECUTION

3.1 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft2 of coil area.{USC}

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure.
   1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
   2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
   3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
   4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
   5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

J. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.2 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.
END OF SECTION
SECTION 23 09 13.43
BAS CONTROL DAMPERS

PART 1 GENERAL

1.1 Related Sections
   .1 SECTION 23 09 00, BAS Instrumentation and Control
   .1 SECTION 23 09 13, BAS Instrumentation and Control Devices
   .2 SECTION 23 09 13.13, BAS Actuators and Operators
   .3 SECTION 23 09 13.23, BAS Sensors and Transmitters
   .4 SECTION 23 09 23, BAS Direct Digital Control System

1.2 References
   .1 Refer to Section 23 09 00 - References

1.3 Acronyms, Abbreviations and Definitions
   .1 Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 PRODUCT

2.1 Automatic Control Dampers
   .1 Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage data for all control dampers with the temperature control submittal.
   .2 Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.
   .3 Provide any automatic control dampers not specified to be integral with other equipment.
   .4 Provide automatic control dampers as specified herein:
      .1 Frame construction shall not be less than 14 gauge galvanized steel or extruded aluminum at a minimum 4-1/2" X 1" X 0.125" in thickness.
      .2 Blades shall be single skin and not less than 16-gauge galvanized steel roll formed or extruded aluminum. Blades shall not be over: 8" wide, 48" in length and 72" high.
      .3 All blade edges and top and bottom of frame shall be provided with compressible seals. Side seals shall be compressible stainless steel of the tight-seal spring type.
      .4 Blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5 inches of WC differential pressure. Dampers and seals shall be suitable for temperature ranges of -40 to 180 °F.
      .5 Bearings shall corrosion resistant, molded synthetic sleeve type turning in an extruded hole in the damper frame.
.6 Axles shall be a minimum of ½” diameter and be welded to blade or riveted to blade.

.7 Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6”.

.8 Where ultra-low leakage dampers are specified the blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 6 CFM per square foot for dampers in excess of sixteen inches square at 1 inch of WC.

.9 Individual damper sections shall not be larger than 48” X 60”. Provide a minimum of one damper actuator per section.

.10 All proportional control dampers shall be opposed or parallel blade type as hereinafter specified and all two-position dampers shall be parallel blade types.

.11 Combination automatic smoke control dampers, where indicated on the plans, shall conform to the UL555S Leakage Class specified.

PART 3 EXECUTION

3.1 Co-ordination

.1 Coordinate delivery of dampers to site.

.2 Clearly tag and mark dampers for their purpose and location.

.3 Supervise Mechanical Contractor in the installation of the dampers ensuring proper dampers(s) are located and installed in proper location(s)

END OF SECTION
SECTION 23 09 23
BAS DIRECT DIGITAL CONTROL (DDC) SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. DDC system for monitoring and controlling of HVAC systems.
   2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:
   1. Section 26 05 53 "Electrical Identification" for identification requirements for electrical components.

1.02 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:
   2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
   3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
   5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. E/P: Voltage to pneumatic.

L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

M. HLC: Heavy load conditions.

N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

O. I/P: Current to pneumatic.

P. LAN: Local area network.

Q. LNS: LonWorks Network Services.

R. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

T. Modbus TCP/IP: An open protocol for exchange of process data.


V. MTBF: Mean time between failures.

W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.
Z. POT: Portable operator’s terminal.
AA. PUE: Performance usage effectiveness.
BB. RAM: Random access memory.
CC. RF: Radio frequency.
DD. Router: Device connecting two or more networks at network layer.
EE. Server: Computer used to maintain system configuration, historical and programming database.
FF. TCP/IP: Transport control protocol/Internet protocol.
GG. UPS: Uninterruptible power supply.
HH. USB: Universal Serial Bus.
II. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
JJ. VAV: Variable air volume.
KK. WLED: White light emitting diode.

1.03 PREINSTALLATION MEETINGS
A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS
A. Multiple Submissions:
   1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
   2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
   3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.
B. Product Data: For each type of product include the following:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
   a. Workstations.
   b. Servers.
   c. Printers.
   d. Gateways.
   e. Routers.
   f. DDC controllers.
   g. Enclosures.
   h. Electrical power devices.
   i. UPS units.
   j. Accessories.
   k. Instruments.
   l. Control dampers and actuators.
   m. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:
   1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
   2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
   3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
   4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
   5. Listing and description of each engineering equation used with reference source.
   6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
   7. Description of operator interface to alphanumeric and graphic programming.
   8. Description of each network communication protocol.
   9. Description of system database, including all data included in database, database capacity and limitations to expand database.
   10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
   11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:
   1. General Requirements:
      a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
      b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
   2. Include plans, elevations, sections, and mounting details where applicable.
   3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:
   a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
   d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
   e. Network communication cable and raceway routing.
   f. Information, drawn to scale, of 1/8" = 1'-0"
   g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
   d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:
   a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
   d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:
    a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches and transmitters.
d. Process signal tubing to sensors, switches and transmitters.

11. Color graphics indicating the following:
   a. Itemized list of color graphic displays to be provided.
   b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
   c. Intended operator access between related hierarchical display screens.

E. System Description:
   1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
   2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
   3. System and product operation under each potential failure condition including, but not limited to, the following:
      a. Loss of power.
      b. Loss of network communication signal.
      c. Loss of controller signals to inputs and outputs.
      d. Operator workstation failure.
      e. Server failure.
      f. Gateway failure.
      g. Network failure
      h. Controller failure.
      i. Instrument failure.
      j. Control damper and valve actuator failure.
   4. Complete bibliography of documentation and media to be delivered to Owner.
   5. Description of testing plans and procedures.
   6. Description of Owner training.

F. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.
   1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
   2. Schedule and design calculations for control dampers and actuators.
      a. Flow at Project design and minimum flow conditions.
      b. Face velocity at Project design and minimum airflow conditions.
      c. Pressure drop across damper at Project design and minimum airflow conditions.
      d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
      e. Maximum close-off pressure.
      f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
      g. Torque required at worst case condition for sizing actuator.
      h. Actuator selection indicating torque provided.
      i. Actuator signal to control damper (on, close or modulate).
      j. Actuator position on loss of power.
      k. Actuator position on loss of control signal.
   3. Schedule and design calculations for control valves and actuators.
      a. Flow at Project design and minimum flow conditions.
      b. Pressure-differential drop across valve at Project design flow condition.
      c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
      d. Design and minimum control valve coefficient with corresponding valve position.
4. Schedule and design calculations for selecting flow instruments.
   a. Instrument flow range.
   b. Project design and minimum flow conditions with corresponding accuracy, control signal
to transmitter and output signal for remote control.
   c. Extreme points of extended flow range with corresponding accuracy, control signal to
transmitter and output signal for remote control.
   d. Pressure-differential loss across instrument at Project design flow conditions.
   e. Where flow sensors are mated with pressure transmitters, provide information for each
instrument separately and as an operating pair.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Systems Provider Qualification Data:
      a. Resume of project manager assigned to Project.
      b. Resumes of application engineering staff assigned to Project.
      c. Resumes of installation and programming technicians assigned to Project.
      d. Resumes of service technicians assigned to Project.
      e. Brief description of past project including physical address, floor area, number of floors,
building system cooling and heating capacity and building's primary function.
      f. Description of past project DDC system, noting similarities to Project scope and
complexity indicated.
      g. Names of staff assigned to past project that will also be assigned to execute work of this
Project.
      h. Owner contact information for past project including name, phone number, and e-mail
address.
      i. Contractor contact information for past project including name, phone number, and e-
mail address.
      j. Architect and Engineer contact information for past project including name, phone
number, and e-mail address.
   2. Manufacturer's qualification data.
   3. Testing agency's qualifications data.

B. Welding certificates.

C. Product Certificates:
   1. Data Communications Protocol Certificates: Certifying that each proposed DDC system
component complies with ASHRAE 135.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.
1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
   1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
      e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
      h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
      i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
      j. List of recommended spare parts with part numbers and suppliers.
      k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
      l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
      m. Licenses, guarantees, and warranty documents.
      n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
      o. Owner training materials.

1.07 MAINTENANCE MATERIAL SUBMITTALS

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

1.08 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:
   1. Nationally recognized manufacturer of DDC systems and products.
   2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
   3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:
   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing and quality control.
   d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
   e. Owner operator training.

B. DDC System Provider Qualifications:
   1. Authorized representative of, and trained by, DDC system manufacturer.
   2. In-place facility located within 50 miles of Project.
   3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
   4. Demonstrated past experience on five projects of similar complexity, scope and value.
   5. Each person assigned to Project shall have demonstrated past experience.
   6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
   7. Service and maintenance staff assigned to support Project during warranty period.
   8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
   9. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.09 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
   1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
   2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
      a. Install updates only after receiving Owner's written authorization.
   3. Warranty Period: 3 year(s) from date of Substantial Completion.
      a. For Gateway: Three-year parts and labor warranty for each.
PART 2 - PRODUCTS

2.01 DDC SYSTEM MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Distech Controls.
   2. Invensys Building Systems.
   3. Reliable Controls Corporation.
   4. Schneider Electric USA, Inc.
   5. Siemens Building Technologies, Inc.

2.02 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
   1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

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

2.03 WEB ACCESS

A. DDC system shall be Web based or Web compatible.
   1. Web-Based Access to DDC System:
      a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet.
      b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
      c. Web access shall be password protected.
   2. Web-Compatible Access to DDC System:
      a. Workstation and or server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
      b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
      c. Web access shall be password protected.

2.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design DDC system to satisfy requirements indicated.

B. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements
indicated.

1. **System Performance Objectives:**
   a. DDC system shall manage HVAC systems.
   b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
   c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
   d. DDC system shall operate while unattended by an operator and through operator interaction.
   e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

C. **Surface-Burning Characteristics:** Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

D. **DDC System Speed:**
   1. **Response Time of Connected I/O:**
      a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
      d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
   2. **Display of Connected I/O:**
      a. Analog point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
      b. Binary point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
      c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.
      d. Graphic display refresh shall update within four seconds.
      e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

E. **Network Bandwidth:** Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

F. **DDC System Data Storage:**
   1. Include capability to archive not less than 12 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
   2. **Local Storage:**
      a. Provide server with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.
3. Cloud Storage:
   a. Provide application-based and web browser interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

G. DDC Data Access:
   1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
   2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

H. Future Expandability:
   1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
   2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
   3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

I. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
   1. Energy:
      a. Thermal: Within 5 percent of reading.
      b. Electric Power: Within 1 percent of reading.
      c. Requirements indicated on Drawings for meters not supplied by utility.
   2. Flow:
      a. Air: Within 5 percent of design flow rate.
      b. Air (Terminal Units): Within 5 Insert number percent of design flow rate.
      c. Water: Within 2 percent of design flow rate.
   3. Moisture (Relative Humidity):
      a. Air: Within 5 percent RH.
      b. Space: Within 5 percent RH.
      c. Outdoor: Within 5 percent RH.
   4. Pressure:
      a. Air, Ducts and Equipment: 1 percent of instrument range.
      b. Water: Within 0.5 percent of instrument range.
   5. Temperature, Dry Bulb:
      a. Air: Within 0.25 deg F.
      b. Space: Within 0.25 deg F.
      c. Outdoor: Within 1 deg F.
      d. Chilled Water: Within 0.1 deg F.
      e. Temperature Difference: Within 0.25 deg F.
      f. Other Temperatures Not Indicated: Within 1 deg F.
   6. Temperature, Wet Bulb:
      a. Air: Within 0.5 deg F.
      b. Space: Within 0.5 deg F.
      c. Outdoor: Within 1 deg F.

J. Precision of I/O Reported Values: Values reported in database and displayed shall have following
precision:
1. Current:
   a. Milliamperes: Nearest 1/100th of a milliampere.
   b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2. Energy:
   a. Electric Power:
      1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
      2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
      3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
   b. Thermal, Rate:
      1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
      2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
   c. Thermal, Usage:
      1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.
      2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 ton-hours above 10,000 tons.
3. Flow:
   a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
   b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
4. Moisture (Relative Humidity):
   a. Relative Humidity (Percentage): Nearest 1 percent.
5. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
6. Pressure:
   a. Air, Ducts and Equipment: Nearest 1/100th in. w.c.
   b. Space: Nearest 1/100th in. w.c.
   c. Steam: Nearest 1/10th psig through 100 psig; nearest psig above 100 psig.
   d. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.
7. Temperature:
   a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
   b. Outdoor: Nearest degree.
   c. Space: Nearest 1/10th of a degree.
   d. Chilled Water: Nearest 1/10th of a degree.
   e. Condenser Water: Nearest 1/10th of a degree.
   f. Heating Hot Water: Nearest degree.
   g. Heat Recovery Runaround: Nearest 1/10th of a degree.
   h. Steam: Nearest degree.
8. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

K. Control Stability: Control variables indicated within the following limits:
   1. Flow:
      a. Air, Ducts and Equipment, except Terminal Units: Within 5 percent of design flow rate.
      b. Air, Terminal Units: Within 5 percent of design flow rate.
c. Water: Within 2 percent of design flow rate.

2. Moisture (Relative Humidity):
   a. Air: Within 3 percent RH.
   b. Space: Within 5 percent RH.
   c. Outdoor: Within 2 percent RH.

3. Pressure:
   a. Air, Ducts and Equipment: 1 percent of instrument range.
   b. Space: Within 1 percent of instrument range.
   c. Water: Within 1 percent of instrument range.

4. Temperature, Dew Point:
   a. Air: Within 0.5 deg F.
   b. Space: Within 0.5 deg F.

5. Temperature, Dry Bulb:
   a. Air: Within 0.5 deg F <Insert value>.
   b. Space: Within 2 deg F.
   c. Chilled Water: Within 1 deg F.

6. Temperature, Wet Bulb:
   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.

L. Environmental Conditions for Controllers, Gateways, and Routers:
1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: Type 3.
   b. Outdoors, Unprotected: Type 4X.
   c. Indoors, Heated with Filtered Ventilation: Type 1.
   d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
   e. Indoors, Heated and Air Conditioned: Type 1.

M. Environmental Conditions for Instruments and Actuators:
1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
   a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

N. Backup Power Source:
1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

O. UPS:
1. DDC system products powered by UPS units shall include the following:
   a. Desktop workstations.
b. Printers.
c. Servers.
d. Gateways.
e. DDC controllers, except application-specific controllers.

P. Continuity of Operation after Electric Power Interruption:
1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.05 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. Manual Override of Control Dampers:
1. Include panel-mounted, two-position, selector switch for each automatic control damper being controlled by DDC controller.
2. Label each switch with damper designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to damper.
4. With switch in "Auto" position signal to control damper actuator shall be control loop output signal from DDC controller.
5. With switch in "Manual" position, signal to damper actuator shall be controlled at panel with either an integral or separate switch to include local control.
   a. For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.
   b. For Analog Control Dampers: A gradual switch shall have "Close" and "Open" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.
6. DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall signal an override condition to alert operator that damper is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller operational.
8. Terminal equipment including VAV units, do not require manual override unless otherwise indicated by sequence of operation.

B. Manual Override of Control Valves:
1. Include panel-mounted, two-position, selector switch for each automatic control valve being controlled by a DDC controller.
2. Label each switch with valve designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to valve.
4. With switch in "Auto" position, signal to control-valve actuator shall be a control loop output signal from DDC controller.
5. With switch in "Manual" position, signal to valve actuator shall be controlled at panel with either an integral or a separate switch to include local control.
   a. For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.
   b. For Analog Control Dampers: A gradual switch shall have "Open" and "Close" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.
6. DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall signal an override condition to alert operator that valve is under manual, not automatic, control.

2.06 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two levels of LANs.
   1. Level one LAN shall connect network controllers and operator workstations.
   2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
   3. Level two or Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.

B. Minimum Data Transfer and Communication Speed:
   1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
   2. LAN Connecting Programmable Application Controllers: 1000 kbps.

C. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its own control, alarm management and historical data collection.

H. Special Network Architecture Requirements:
   1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.
   2. <Insert additional requirements>.

2.07 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
   1. Desktop and portable workstation with hardwired connection through LAN port.
   2. Portable operator terminal with hardwired connection through LAN port.
   3. Portable operator workstation with wireless connection through LAN router.
   4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
   5. Remote connection through web access.
B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
   1. Each mechanical equipment room.
   2. Each chiller room or outdoor chiller yard.
   3. Each different roof level with roof-mounted air-handling units or rooftop units.
   5. Fire-alarm system command center.

D. Desktop Workstations:
   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:
   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on any DDC system LAN.
   3. Connect to DDC system Level two or Level three LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
   4. Connect to system through a wireless router connected to Level one LAN.
   5. Connect to system through a cellular data service.
   6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
   7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
   8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:
   1. Connect DDC controller through a communications port local to controller.
   2. Able to communicate with any DDC system controller that is directly connected or with LAN.

G. Mobile Device:
   1. Connect to system through a wireless router connected to LAN and cellular data service.
   2. Able to communicate with any DDC controller connected to DDC system using a dedicated application and secure web access.

H. Critical Alarm Reporting:
   1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
   2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
   3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

I. Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.08 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include

Trinity Valley Community College Submittal Procedures
Health Science Center 50% CD’S / GMP Pricing
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the following:
1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

2.09 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:
   1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
   2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
   3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
   4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.10 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

B. Performance Requirements:
   1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
   2. Energy Star compliant.

C. Wireless Ethernet, 802.11 a/b/g/n/ac.
   1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
   2. I/O Ports:
      a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
      b. One serial port.
      c. One stereo line-in and headphone/line-out on back panel.
      d. One microphone and headphone connector on front panel.
   3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

D. Keyboard:
   1. 101 enhanced keyboard.
   2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
   3. Wireless operation within up to 72 inches in front of workstation.

E. Pointing Device:
   1. Either a two- or three-button mouse.
   2. Wireless operation within up to 72 inches in front of workstation.
F. Flat Panel Display Monitor:
   1. Display:
      a. Color display with 24" diagonal viewable area.
      b. Digital input signal.
      d. Antiglare display.
      e. Dynamic Contrast Ratio: 1000000 to 1.
      f. Brightness: 250 cd/sq. m.
      g. Tilt adjustable base.
      h. Energy Star compliant.
      i. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.24 mm or smaller.
      j. Number of Displays: Two.

G. Speakers:
   1. Two, with individual controls for volume, bass and treble.
   2. Signal to Noise Ratio: At least 65 dB.
   3. Power: At least 4 W per speaker/channel.
   4. Magnetic shielding to prevent distortion on the video monitor.

H. I/O Cabling: Include applicable cabling to connect I/O devices.

2.11 PRINTERS

A. Color Laser Printer:
   1. 1200 by 1200 dots per inch resolution black and white, 600 x 600 dots per inch resolution black and white and color.
   2. First sheet printed within 10 seconds.
   3. Complies with Energy Star requirements.
   4. Two paper trays.
   5. Two-sided printing.

2.12 SYSTEM SOFTWARE

A. System Software Minimum Requirements:
   1. Real-time multitasking and multiuser 32- or 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
   2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
   3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
   4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
   5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
   6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:
1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
   a. Operator access to DDC system shall be under password control.
   b. An alphanumeric password shall be field assignable to each operator.
   c. Operators shall be able to access DDC system by entry of proper password.
   d. Operator password shall be same regardless of which computer or other interface means is used.
   e. Additions or changes made to passwords shall be updated automatically.
   f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
   g. Software shall have at least five access levels.
   h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
   i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
7. Data Segregation:
   a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
   b. Include at least 32 segregation groups.
   c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
   d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
   e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
   f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
8. Operators shall be able to perform commands including, but not limited to, the following:
   a. Start or stop selected equipment.
   b. Adjust set points.
   c. Add, modify, and delete time programming.
   d. Enable and disable process execution.
   e. Lock and unlock alarm reporting for each point.
   f. Enable and disable totalization for each point.
   g. Enable and disable trending for each point.
   h. Override control loop set points.
   i. Enter temporary override schedules.
   j. Define holiday schedules.
   k. Change time and date.
   l. Enter and modify analog alarm limits.
   m. Enter and modify analog warning limits.
   n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.
r. <Insert requirements>.

9. Reporting:
a. Generated automatically and manually.
b. Sent to displays, printers and disk files.
c. Types of Reporting:
   1) General listing of points.
   2) List points currently in alarm.
   3) List of off-line points.
   4) List points currently in override status.
   5) List of disabled points.
   6) List points currently locked out.
   7) List of items defined in a "Follow-Up" file.
   8) List weekly schedules.
   9) List holiday programming.
   10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:
1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
   a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
   b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
   c. Keyboard equivalent shall be available for those operators with that preference.
20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:
   a. On-line context-sensitive help utility to facilitate operator training and understanding.
   b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
      1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
   c. Available for Every Menu Item:
      1) Index items for each system menu item.
22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
   a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
   b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
      1) Define background screens.
      2) Define connecting lines and curves.
      3) Locate, orient and size descriptive text.
      4) Define and display colors for all elements.
      5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
   a. Room layouts with room identification and name.
   b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
   c. Location and identification of each hardware point being controlled or monitored by DDC system.
3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and
dynamic value indication, sequence of operation and control logic diagram.

4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.

5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways.

E. Customizing Software:
1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.

2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.

3. As a minimum, include the following modification capability:
   a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
   b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
   c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
   d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
   e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
   f. Point related change capability shall include the following:
      1) System and point enable and disable.
      2) Run-time enable and disable.
      3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
      4) Assignment of alarm and warning limits.
   g. Application program change capability shall include the following:
      1) Enable and disable of software programs.
      2) Programming changes.
      3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
   a. Proportional control (P).
   b. Proportional plus integral (PI).
   c. Proportional plus integral plus derivative (PID).
   d. Adaptive and intelligent self-learning control.
1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.

2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.

2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.

4. Alarms display shall include the following:
   a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
   b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
   c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
   d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

6. Send e-mail alarm messages to designated operators.

7. Send e-mail, page, text and voice messages to designated operators for critical alarms.

8. Alarms shall be categorized and processed by class.
   a. Class 1:
      1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
      2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
      3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.
   b. Class 2:
      1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
      2) Acknowledgement may be through a multiple alarm acknowledgment.
   c. Class 3:
      1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
      2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
      3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
      4) Alarms returning to normal condition shall be printed and not cause an audible
sound or require acknowledgment.

d. Class 4:
   1) Routine maintenance or other types of warning alarms.
   2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:
1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation and server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
   1. All I/O: With current status and values.
   2. Alarm: All current alarms, except those in alarm lockout.
   3. Disabled I/O: All I/O points that are disabled.
   4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
   5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
   6. Logs:
      a. Alarm history.
      b. System messages.
      c. System events.
      d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Tenant Override Reports: Prepare Project-specific reports.
   1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
   2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
   3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

K. HVAC Equipment Reports: Prepare Project-specific reports.
   1. Chiller Report: Daily report showing operating conditions of each chiller according to ASHRAE 147, including, but not limited to, the following:
      a. Refrigerant levels.
      b. Oil pressure and temperature.
      c. Oil level.
d. Compressor refrigerant discharge temperature.
e. Compressor refrigerant suction temperature.
f. Addition of refrigerant.
g. Addition of oil.
h. Vibration levels or observation that vibration is not excessive.
i. Motor amperes per phase.
j. Motor volts per phase.
k. Refrigerant monitor level (PPM).
l. Purge exhaust time or discharge count.
m. Ambient temperature (dry bulb and wet bulb).
n. Date and time logged.

L. Utility Reports: Prepare Project-specific reports.
   1. Electric Report:
      a. Include weekly report showing daily electrical consumption and peak electrical demand
         with time and date stamp for each meter.
      b. Include monthly report showing the daily electrical consumption and peak electrical
         demand with time and date stamp for each meter.
      c. Include annual report showing the monthly electrical consumption and peak electrical
         demand with time and date stamp for each meter.
      d. For each weekly, monthly and annual report, include sum total of submeters combined
         by load type, such as lighting, receptacles and HVAC equipment showing daily
         electrical consumption and peak electrical demand.
      e. For each weekly, monthly and annual report, include sum total of all submeters in
         building showing electrical consumption and peak electrical demand.

M. Energy Reports: Prepare Project-specific daily, weekly, monthly, annual and since-installed
   energy reports.
   1. Prepare report for each purchased energy utility, indicating the following:
      a. Time period being reported with beginning and end date, and time indicated.
      b. Consumption in units of measure commonly used to report specific utility consumption
         over time.
      c. Gross area served by utility.
      d. Consumption per unit area served using utility-specific unit of measure.
      e. Cost per utility unit.
      f. Utility cost per unit area.
      g. Convert all utilities to a common energy consumption unit of measure and report for
         each utility.
      h. Consumption per unit area using common unit of measure.
   2. Prepare report for each renewable energy source, indicating the following:
      a. Time period being reported with beginning and end date, and time indicated.
      b. Harvested energy in units of measure commonly used to report specific harvested
         energy consumption over time.
      c. Gross area served by renewable energy source.
      d. Harvested energy per unit area served using specific unit of measure.
      e. Cost per purchased utility unit displaced by renewable energy.
      f. Cost savings attributed to harvested energy source.
      g. Cost savings per unit area attributed to harvested energy.
      h. Convert all renewable energy sources to a common energy consumption unit of
         measure and report for each.
      i. Harvested energy per unit area using common unit of measure.
   3. Prepare purchased energy utility report for each submetered area that indicates the
      following:
      a. Time period being reported with beginning and end date, and time indicated.
b. Gross area served.
c. Energy consumption by energy utility type.
d. Energy consumption per unit area by energy utility type.
e. Total energy consumption of all utilities in common units of measure.
f. Total energy consumption of all utilities in common units of measure per unit area.
g. Unit energy cost by energy utility type.
h. Energy cost by energy utility type.
i. Energy cost per unit area by energy utility type.
j. Total cost of all energy utilities.
k. Total cost of all energy utilities per unit area.

4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:
   a. Time period being reported with beginning and end date, and time indicated.
   b. Gross area served.
   c. Energy consumption by energy utility type.
   d. Energy consumption per unit area by energy utility type.
   e. Total energy consumption of all utilities in common units of measure.
   f. Total energy consumption of all utilities in common units of measure per unit area.
   g. Unit energy cost by energy utility type.
   h. Energy cost by energy utility type.
   i. Energy cost per unit area by energy utility type.
   j. Total cost of all energy utilities.
   k. Total cost of all energy utilities per unit area.

N. Standard Trends:
   1. Trend all I/O point present values, set points, and other parameters indicated for trending.
   2. Trends shall be associated into groups, and a trend report shall be set up for each group.
   3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
   4. Preset trend intervals for each I/O point after review with Owner.
   5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
   6. When drive storage memory is full, most recent data shall overwrite oldest data.
   7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

O. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
   1. Each trend shall include interval, start time, and stop time.
   2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
   3. Data shall be retrievable for use in spreadsheets and standard database programs.

P. Programming Software:
   1. Include programming software to execute sequences of operation indicated.
   2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
   3. Programming software shall be [as follows] [any of the following] [one of the following]:
      a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
         1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
         2) Programming tools shall be viewable in real time to show present values and
logical results of each function block.

b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.

c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

Q. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.

2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.

3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
   a. Backup.
   b. Purge.
   c. Restore.

4. Database management software shall support the following:
   a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
   b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
   c. Backup: Include means to create a database backup file and select a storage location.
   d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:
   a. Ready.
   b. Purging record from a database.
   c. Action failed.
   d. Refreshing statistics.
   e. Restoring database.
   f. Shrinking a database.
   g. Backing up a database.
   h. Resetting Internet information services.
   i. Starting network device manager.
   j. Shutting down the network device manager.
   k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.

7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.

8. Monitoring settings window shall have the following sections:
   a. Allow operator to set and review scan intervals and start times.
   b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
   c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
   d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link
e-mail message.
e. Database Login: Protect system from unauthorized database manipulation by creating a
read access and a write access for each of trend, alarm, event and audit databases as
well as operator proper security access to restore a database.
9. Monitoring settings taskbar shall include the following informational icons:
a. Normal: Indicates by color and size, or other easily identifiable means that all databases
are within their limits.
b. Warning: Indicates by color and size, or other easily identifiable means that one or more
databases have exceeded their warning limit.
c. Alarm: Indicates by color and size, or other easily identifiable means that one or more
databases have exceeded their alarm limit.

2.13 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard
option, for integration via a single communication cable. BACnet-controlled plant equipment
includes, but is not limited to, chillers, pumps, air handlers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and
existing non-BACnet DDC-controlled equipment, only when specifically requested and approved
by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy
side that BACnet "client" will read, and each parameter that BACnet network will write to.
Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:
   1. Read and view all readable object properties on non-BACnet network to BACnet network
      and vice versa where applicable.
   2. Write to all writeable object properties on non-BACnet network from BACnet network and
      vice versa where applicable.
   3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation
      from non-BACnet protocol to BACnet and vice versa.
   4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property,
      Device Management Dynamic Device Binding-B, and Device Management Communication
      Control BIBBs according to ASHRAE 135.
   5. Hardware, software, software licenses, and configuration tools for operator-to-gateway
      communications.
   6. Backup programming and parameters on CD media and the ability to modify, download,
      backup, and restore gateway configuration.

2.14 WIRELESS ROUTERS FOR OPERATOR INTERFACE

A. Dual-Band Wireless Routers:
   1. Description: High-speed, dual-band router with integral Ethernet ports and USB port.
   2. Technology: IEEE 802.11n; 2.4- and 5-GHz speed bands.
   3. Speed: Up to 300 Mbps on 2.4-GHz band and up to 450 Mbps on 5-GHz band.
   4. Compatibility: IEEE 802.11n/g/b/a wireless devices.
   5. Ethernet Ports: Four, gigabit (1000 Mbps).
   6. USB Port: One, USB 2.0 or 3.0.
   7. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.
2.15 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
   3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:
   1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
   2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. Maintenance and Support: Include the following features to facilitate maintenance and support:
   1. Mount microprocessor components on circuit cards for ease of removal and replacement.
   2. Means to quickly and easily disconnect controller from network.
   3. Means to quickly and easily access connect to field test equipment.
   4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

H. Input and Output Point Interface:
   1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
   2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
   3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
   4. AIs:
      a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
      b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
      c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
      d. Signal conditioning including transient rejection shall be provided for each AI.
      e. Capable of being individually calibrated for zero and span.
      f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
   5. AOs:
      a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
      b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to
include proper control of output device.

c. Capable of being individually calibrated for zero and span.

d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:
   a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-
      ms duration.
   b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
   c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly
      available control devices and shall be protected against effects of contact bounce and
      noise.
   d. BIs shall sense "dry contact" closure without external power (other than that provided by
      the controller) being applied.
   e. Pulse accumulation input points shall comply with all requirements of BIs and accept up
      to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize
      pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The
      totalized value shall be reset to zero on operator's command.

7. BOs:
   a. Controller BOs shall include relay contact closures or triac outputs for momentary and
      maintained operation of output devices.
      1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall
         include at least 180 V of isolation. Electromagnetic interference suppression shall
         be provided on all output lines to limit transients to non-damaging levels. Minimum
         contact rating shall be 1 A at 24-V ac.
      2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall
         be 1 A at 24-V ac.
   b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width
      modulation control.
   c. BOs shall be selectable for either normally open or normally closed operation.
   d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type
      electronic actuators without feedback.
   e. Limit use of three-point floating devices to VAV terminal unit control applications.
      Control algorithms shall operate actuator to one end of its stroke once every 24 hours
      for verification of operator tracking.

2.16 NETWORK CONTROLLERS

A. General Network Controller Requirements:
   1. Include adequate number of controllers to achieve performance indicated.
   2. System shall consist of one or more independent, standalone, microprocessor-based
      network controllers to manage global strategies indicated.
   3. Controller shall have enough memory to support its operating system, database, and
      programming requirements.
   4. Data shall be shared between networked controllers and other network devices.
   5. Operating system of controller shall manage input and output communication signals to allow
      distributed controllers to share real and virtual object information and allow for central
      monitoring and alarms.
   6. Controllers shall have a real-time clock.
   7. Controller shall continually check status of its processor and memory circuits. If an abnormal
      operation is detected, controller shall assume a predetermined failure mode and generate an
      alarm notification.
   8. Controllers shall be fully programmable.

B. Communication:

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1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:
1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:
   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.17 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:
1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:
1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:
1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:
   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.
   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:
   1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

B. Communication Interface to Other Building Systems:
   1. DDC system shall have a communication interface with systems having a communication interface.

3.03 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

3.04 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 07 84 13 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 92 00 "Joint Sealants."

H. Welding Requirements:
1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:
1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.
2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.05 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:
1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.
B. Portable Workstations Installation:
   1. Turn over portable workstations to Owner at Substantial Completion.
   2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:
   1. Use system schematics indicated as starting point to create graphics.
   2. Develop Project-specific library of symbols for representing system equipment and products.
   3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
   4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
   5. Seek Owner input in graphics development once using graphics software.
   6. Final editing shall be done on-site with Owner's review and feedback.
   7. Refine graphics as necessary for Owner acceptance.
   8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.06 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.
   1. Install gateway(s) required to suit indicated requirements.

B. Test gateway to verify that communication interface functions properly.

3.07 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.
   1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.08 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:
   1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
   2. Install controllers in a protected location that is easily accessible by operators.
   3. Top of controller shall be within 72 inches of finished floor.
F. Installation of Programmable Application Controllers:
1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:
1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.09 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:
1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for identification products and installation.
B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
1. Operator workstation.
2. Server.
3. Printer.
4. Gateway.
5. Router.
7. DDC controller.
8. Enclosure.
9. Electrical power device.
10. UPS unit.
11. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:
1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.12 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:
1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:
1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment is secure.
4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.

H. Instrument Checkout:
1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
   a. Verify sensing element type and proper material.
   b. Verify length and insertion.

3.13 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. 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
K. Digital Signals:
   1. Check digital signals using a jumper wire.
   2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:
   1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
   3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
   4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:
   1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
   3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
   4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:
   1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
   2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.14 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.
   1. Verify voltage, phase and hertz.
   2. Verify that protection from power surges is installed and functioning.
   3. Verify that ground fault protection is installed.
   4. If applicable, verify if connected to UPS unit.
   5. If applicable, verify if connected to a backup power source.
   6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.
3.15 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:
1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.16 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:
   1. Detailed explanation for any items that are not completed or verified.
   2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
   3. HVAC equipment motors operate below full-load amperage ratings.
   4. Required DDC system components, wiring, and accessories are installed.
   5. Installed DDC system architecture matches approved Drawings.
   6. Control electric power circuits operate at proper voltage and are free from faults.
   7. Required surge protection is installed.
   8. DDC system network communications function properly, including uploading and downloading programming changes.
   9. Using BACnet protocol analyzer, verify that communications are error free.
   10. Each controller’s programming is backed up.
   11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
   12. All I/O points are programmed into controllers.
   13. Testing, adjusting and balancing work affecting controls is complete.
   14. Dampers and actuators zero and span adjustments are set properly.
   15. Each control damper and actuator goes to failed position on loss of power.
   16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:
1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:
1. Verify operating performance of each I/O point in DDC system.
   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.
      1) Identify I/O points for future reference.
      2) Simulate abnormal conditions to demonstrate proper function of safety devices.
      3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. After 24 Hours of Second Validation Test:
   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Network Bandwidth Test:
1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.
3.17 DDC SYSTEM WIRELESS NETWORK VERIFICATION

A. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.

B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.

C. Testing and verification of all wireless devices shall include, but not be limited to, the following:
   1. Speed.
   2. Online status.
   3. Signal strength.

3.18 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall 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. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.
   1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
   2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
   3. Demonstration shall include, but not be limited to, the following:
      a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
      b. HVAC equipment and system hardwired and software safeties and life-safety functions
are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
f. Trends, summaries, logs and reports set-up for Project.
g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
i. Software's ability to edit control programs off-line.
j. Data entry to show Project-specific customizing capability including parameter changes.
k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
l. Execution of digital and analog commands in graphic mode.
m. Spreadsheet and curve plot software and its integration with database.
n. Online user guide and help functions.
o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
p. System speed of response compared to requirements indicated.
q. For Each [Network] [and] [Programmable Application] Controller:
   1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
   2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
   3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
   4) Electric Power: Ability to disconnect any controller safely from its power source.
   5) Wiring Labels: Match control drawings.
   6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
   7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.
r. For Each Operator Workstation:
   1) I/O points lists agree with naming conventions.
   2) Graphics are complete.
   3) UPS unit, if applicable, operates.
s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.
   1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
   2) Reading of Any Property: Demonstrate ability to read and display any used
3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. [Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.]

4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.

5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.

6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.

7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.

8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.

9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

10) Device and Network Management:
    a) Display of network device status.
    b) Display of BACnet Object Information.
    c) Silencing devices transmitting erroneous data.
    d) Time synchronization.
    e) Remote device re-initialization.
    f) Backup and restore network device programming and master database(s).
    g) Configuration management of routers.

3.19 EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of DDC system by Owner.

B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.

D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
   1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:
   1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
   2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.
3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
5. Downtime shall be logged in hours to nearest 0.1 hour.
6. Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.
   1. Identify source of problem.
   2. Provide written description of corrective action taken.
   3. Record duration of downtime.
   4. Maintain log showing the following:
      a. Time of occurrence.
      b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
      c. Downtime for each failed I/O point.
      d. Running total of downtime and total time of I/O point after each problem has been restored.
   5. Log shall be available to Owner for review at any time.

G. For DDC system to pass extended operation test, total downtime shall not exceed 2 percent of total point-hours during operating period.
   1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.

H. Evaluation of DDC system passing test shall be based on the following calculation:
   1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
   2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
   3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

3.20 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.
3.21 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:
1. Base extent of training on scope and complexity of DDC 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 not less than five days 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 not more than two separate training classes.
   d. Each training class shall be not less than two consecutive day(s).

C. Training Outline:
1. Submit training outline for Owner review at least 10 business days before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

D. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

E. Video of Training Sessions:
1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION
SECTION 23 09 93

BAS SEQUENCES OF OPERATIONS

PART 1  GENERAL

1.1  SEQUENCES OF OPERATION

A.  Refer to drawings for Sequences of Operation and Control Diagrams.

PART 2  PRODUCTS

1.  Not applicable

PART 3  EXECUTION

2.  Not Applicable

END OF SECTION
SECTION 231123
FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

1.5 ACTION SUBMITTALS

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

1. Piping specialties.
2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Indicate pressure ratings and capacities.
4. Dielectric fittings.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.
B. Field quality-control reports.

1.7 QUALITY ASSURANCE

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

1.8 DELIVERY, STORAGE, AND HANDLING

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

1.9 PROJECT CONDITIONS

A. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Construction Manager and Owner written permission.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.
B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

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.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   2. Corrugated stainless-steel tubing with polymer coating.
   3. Operating-Pressure Rating: 0.5 psig.
   5. Threaded Ends: Comply with ASME B1.20.1.
   6. Maximum Length: 72 inches

B. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS


B. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 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. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
2. Ball: Chrome-plated brass.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Separate packnut with adjustable-stem packing threaded ends.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

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.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

2. Springs: Zinc-plated steel; interchangeable.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure 5 psig.

2.6 DIELECTRIC FITTINGS

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

B. Dielectric Unions:
1. Description:
   b. Pressure Rating: 150 psigdeg.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Description:
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: 150 psigdeg.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

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

PART 3 - EXECUTION

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

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

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

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

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. 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.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. 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.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
3.4 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.5 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.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.7 CONNECTIONS

A. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

B. Install piping adjacent to appliances to allow service and maintenance of appliances.

C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.9 PAINTING

A. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   b. Topcoat: Interior latex semigloss.
   c. Color: Yellow.

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with steel welding fittings and welded joints.
3.12 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves in branch piping for single appliance shall be the following:

1. One-piece, bronze ball valve with bronze trim.

END OF SECTION 231123
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. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.

B. Related Sections:
   1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
   2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   4. Elevation of top of ducts.
   5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

D. Welding certificates.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:


B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Duct Dimensions: For rectangular ducts, indicated dimensions are the free area dimensions of the duct. For flat oval ducts, indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the free area. For double wall round ducts, indicated dimension is the inside diameter of the duct.

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   2. Finishes for Surfaces Exposed to View: Prepared for field painting using “Paint Grip” finish.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.
   2. Maximum Thermal Conductivity:
      a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 3 inches minimum.


5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F.
9. **Substrate:** Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### C. Water-Based Joint and Seam Sealant:

1. **Application Method:** Brush on.
2. **Solids Content:** Minimum 65 percent.
3. **Shore A Hardness:** Minimum 20.
4. **Water resistant.**
5. **Mold and mildew resistant.**
6. **VOC:** Maximum 75 g/L (less water).
7. **Maximum Static-Pressure Class:** 10-inch wg, positive and negative.
8. **Service:** Indoor or outdoor.
9. **Substrate:** Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

### D. Flanged Joint Sealant: Comply with ASTM C 920.

1. **General:** Single-component, acid-curing, silicone, elastomeric.
2. **Type:** S.
3. **Grade:** NS.
4. **Class:** 25.
5. **Use:** O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

### F. Round Duct Joint O-Ring Seals:

1. **Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.**
2. **EPDM O-ring to seal in concave bead in coupling or fitting spigot.**
3. **Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.**

#### 2.6 HANGERS AND SUPPORTS

### A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

### B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

### C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

### D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

### E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

### F. Trapeze and Riser Supports:

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and as follows:
   1. Outdoor, Supply-Air Ducts: Seal Class A.
   2. Outdoor, Exhaust Ducts: Seal Class A.
   3. Outdoor, Return-Air Ducts: Seal Class A.
   4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
   5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
   6. Unconditioned Space, Exhaust Ducts: Seal Class B.
   7. Unconditioned Space, Return-Air Ducts: Seal Class B.
   8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
   9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
  10. Conditioned Space, Exhaust Ducts: Seal Class B.
  11. Conditioned Space, Return-Air Ducts: Seal Class B.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3.5 CONNECTIONS
A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING
A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL
A. Perform tests and inspections.
B. Leakage Tests:
   2. Test the following systems:
      a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
      b. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      c. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      d. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      e. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
   6. Give seven days' advance notice for testing.
C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.

B. Supply Ducts:
   1. Ducts Connected to Dedicated Outdoor Air Units and Variable-Volume A/C Units:
      a. Pressure Class, within 20 feet of A/C Unit: Positive 4-inch wg.
      b. Pressure Class, greater than 20 feet from A/C Unit: Positive 2-inch wg.
      c. Exposed to view in public areas: Round spiral or flat oval, lined with 1" acoustical duct liner. Increase duct liner thickness to 2" within 20 feet of A/C unit.
      d. Concealed: Rectangular, flat oval, or round. Ductwork within 20 feet of air handler discharge shall be lined with 2" acoustical duct liner.

C. Return Ducts:
   1. Ducts Connected to Variable-Volume A/C Units:
      a. Pressure Class, within 20 feet of A/C Unit: Positive and negative 4-inch wg.
      b. Pressure Class, greater than 20 feet from A/C Unit: Positive and negative 2-inch wg.
      c. Exposed to view: Round or flat oval. Provide 2" acoustical duct liner within 20 feet of A/C unit.
      d. Concealed: Rectangular, flat oval, or round. Ductwork within 20 feet of air handler discharge shall be lined with 2" acoustical duct liner.

D. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 1-inch wg.
      b. Exposed to view: Galvanized G60 round spiral or flat oval
      c. Concealed: Rectangular, round, or flat oval

E. Intermediate Reinforcement:

F. Liner:
1. All ducts shall be lined as follows, unless noted otherwise, in specification Section 23 07 00 or on drawings:
   a. Supply Air Ducts: Fibrous glass, Type I.
   b. Return Air Ducts: Fibrous glass, Type I.
   c. Exhaust Air Ducts: No Liner. Reference insulation specification for insulation requirements.
   d. Transfer Ducts and Relief Hood Ducts/Boots: Fibrous glass, Type I, 1 inch thick.
   e. Supply and Return Ducts located indoors shall have a minimum R-Value of R-5.
   f. Supply and Return Ducts located outdoors shall have a minimum R-Value of R-8.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Radius-to-Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

END OF SECTION
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. Fire dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Duct silencers.
8. Turning vanes.
9. Duct-mounted access doors.
10. Flexible connectors.
11. Flexible ducts.
12. Duct accessory hardware.

B. Related Sections:

1. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Division 28 Section "Digital, Addressable Fire Alarm System" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

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. Fire-damper, combination fire- and smoke-damper, including sleeves; and duct-mounted access doors and remote damper operators.
   d. 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. Source quality-control reports.

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

1.4 QUALITY ASSURANCE


B. Comply with AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

2. Exposed-Surface Finish: Mill phosphatized.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

2. Nailor Industries Inc.
3. Pottorff; a division of PCI Industries, Inc.
4. Ruskin Company.
B. Description: Gravity balanced.


D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.063-inch thick extruded aluminum with welded corners and mounting flange.

F. Blades: Multiple single-piece blades maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked or Neoprene, mechanically locked.

I. Blade Axles:
   1. Material: Galvanized steel or Aluminum.
   2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Counterweights and spring-assist kits for vertical airflow installations.
   3. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Nailor Industries Inc.
   3. Pottorff; a division of PCI Industries, Inc.
   4. Ruskin Company.

B. Suitable for horizontal or vertical mounting.


D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.063-inch thick extruded aluminum with welded corners and mounting flange.

F. Blades:
   1. Multiple, 0.025-inch thick, roll-formed aluminum.
3. Action: Parallel.
5. Eccentrically pivoted.

G. Blade Seals: Vinyl or Neoprene.

H. Blade Axles: Galvanized steel or Nonferrous metal.

I. Tie Bars and Brackets:
   1. Material: Aluminum.
   2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel.

L. Accessories:
   1. Flange on intake.
   2. Adjustment device to permit setting for varying differential static pressures.

2.4 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. McGill AirFlow LLC.
      b. Nailor Industries Inc.
      c. Pottorff; a division of PCI Industries, Inc.
      d. Ruskin Company.
   2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
   3. Suitable for horizontal or vertical applications.
   4. Frames:
      a. Galvanized or Stainless-steel channels, 0.064 inch thick.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized or Stainless, roll-formed steel, 0.064 inch thick.
   7. Bearings:
      a. Oil-impregnated bronze, Molded synthetic, Stainless-steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

10. Tie Bars and Brackets: Galvanized steel or Aluminum.
11. Accessories:
   a. Include locking device to hold single-blade dampers in a fixed position without vibration.

B. Jackshaft:
   2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:
   2. Include center hole to suit damper operating-rod size.
   3. Include elevated platform for insulated duct mounting.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. McGill AirFlow LLC.
   3. Nailor Industries Inc.
   4. Pottorff; a division of PCI Industries, Inc.
   5. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.


2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Nailor Industries Inc.
   3. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Damper frame shall be 16 ga. galvanized steel formed into a 5” x 1” structural hat channel. Top and bottom frame members on dampers less than 17” high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 ½” (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.

F. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Damper blades shall be 16 ga. galvanized steel with full length structural reinforcement and a double skin airfoil shape. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application.

K. Master control panel for use in dynamic smoke-management systems.

L. Damper Motors: Modulating action.

M. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control for HVAC." And Division 26 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

N. Accessories:
1. Auxiliary switches for signaling, fan control, and position indication.
2. Test and reset switches, remote mounted.

2.7 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. IAC.
   2. Dynasonics
   3. Ruskin Company.
   5. Kinetics

B. General Requirements:
   1. Factory fabricated.
   2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
   3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Shape:
   1. Rectangular straight with splitters or baffles.
   2. Round straight with center bodies or pods.
   3. Rectangular elbow with splitters or baffles.
   4. Round elbow with center bodies or pods.
   5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.052 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.

G. Special Construction:
   1. Suitable for outdoor use, where shown outdoors on plans.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
   1. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   2. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Accessories:
   1. Factory-installed end caps to prevent contamination during shipping.

2.8 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. SEMCO Incorporated.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vaners and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 36 inches wide and double wall for larger dimensions.
2.9 DUCT-MOUNTED ACCESS DOORS

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

2. McGill AirFlow LLC.
3. Nailor Industries Inc.
4. Pottorff; a division of PCI Industries, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.

2.10 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabs, Inc.
B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

   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.

   1. Minimum Weight: 24 oz./sq. yd..
   3. Service Temperature: Minus 50 to plus 250 deg F.

2.11 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flexmaster U.S.A., Inc.
   2. McGill AirFlow LLC.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.

C. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts, at least 7 duct diameters from outlet. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

   1. Install steel volume dampers in steel ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and combination fire/smoke dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. Upstream or downstream from duct silencers.
   8. Control devices requiring inspection.
   9. 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 Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect diffusers to ducts directly or with maximum 60-inch lengths of flexible duct clamped in place. Do not use flexible ducts to change directions
   1. Connect flexible ducts to metal ducts with liquid adhesive plus stainless steel band clamp. Installation must comply with ASHRAE/IESNA 90.1-2016

P. Install duct test holes where required for testing and balancing purposes.

3.2 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 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.

END OF SECTION
SECTION 23 34 23
HVAC POWER 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. Centrifugal roof ventilators.

1.3 PERFORMANCE REQUIREMENTS
A. Project Altitude: Base fan-performance ratings on sea level.
B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
D. Field quality-control reports.
E. Operation and Maintenance Data: For power ventilators 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, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 EXTRA MATERIALS

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

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

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

2. Loren Cook Company.
3. Twin City Fans

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:
1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers (Lab Exhaust Fans): Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Overall Height: 12 inches, 8-inch minimum above finished roof surface.

2.2 MOTORS
A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
B. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL
A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION
3.1 INSTALLATION
A. Install power ventilators level and plumb.
B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 07 Section "Roof Accessories" for installation of roof curbs.
C. Install units with clearances for service and maintenance.
D. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS
A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
B. Install ducts adjacent to power ventilators to allow service and maintenance.

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

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

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   10. Shut unit down and reconnect automatic temperature-control operators.
   11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION
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. Single-duct supply air terminal units with electric heat.
   2. Fan-powered air terminal units with electric heat.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

   1. Air terminal units.
   2. Liners and adhesives.
   3. Sealants and gaskets.

B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.7 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. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

1.8 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 SINGLE-DUCT SUPPLY AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide Single Duct Supply Air Terminal Units from one of the following:

1. Environmental Technologies.
2. Metal-Aire.
5. Titus.

B. Casing: Construct of sheet metal of the following minimum thickness: Upstream Pressure Side, 24-ga; Downstream Pressure Side, 26-ga.

1. Casing Lining: Adhesive attached, minimum 1-inch-thick (R-4.2), polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Velocity Sensor: Multipoint array designed to measure velocity pressure located in primary air inlet with sensing tubes routed to unit controller.

1. Location: Air outlet.
2. Stage(s): As shown on schedules.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Silent magnetic contactor for each step of control.

E. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage required for DDC controller. DDC controller provided by BAS manufacturer for factory installation.
2. Wiring Terminations: Terminal strip with sufficient lugs for factory and field wiring. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

F. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

G. Electronic Direct Digital Controls: Provided by Building Automation System manufacturer. Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices are specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, powered open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet; factory calibrated to minimum and maximum air volumes, and having the following features:
   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Room Sensor: Wall mounted with temperature set-point adjustment, tenant override pushbutton, and access for connection of portable operator terminal.
   d. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."

H. Control Sequence:

1. Occupied (Primary Airflow On):
   a. Operate as throttling control for cooling to maintain occupied space temperature setpoint.
   b. As cooling requirement decreases, control valve throttles toward minimum airflow.

2. Unoccupied (Primary Airflow Off):
   a. Operate as throttling control for cooling to maintain unoccupied space temperature setpoint.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.

2.2 PARALLEL FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide Parallel Fan-Powered Air Terminal Units from one of the following:

1. Environmental Technologies.
2. Metal-Aire.
5. Titus.

B. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.

C. Casing: Construct of sheet metal of the following minimum thickness: Upstream Pressure Side, 24-ga; Downstream Pressure Side, 26-ga.

   1. Casing Lining: Adhesive attached, minimum 1-inch-thick (R-4.2), polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
   5. Fan: Forward-curved centrifugal, located at plenum air inlet.
   6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring or cross configuration and peripheral gasket and self-lubricating bearings.

   1. Maximum Damper Leakage: ARI 880 rated, 4 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensor: Multipoint array designed to measure velocity pressure located in primary air inlet with sensing tubes routed to unit controller.

F. Motor:

   1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.”
   2. Type: Permanent-split capacitor with SCR for speed adjustment or electronically commutated motor.
   4. Enclosure: Open dripproof.

   a. Speed Control: Infinitely adjustable with solid state controls.
G. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Material: 1 inch, pleated cotton-polyester media having 90 percent arrestance and 7 MERV.

   1. Location: Air outlet.
   2. Stage(s): As shown on schedules.
   3. Access door interlocked disconnect switch.
   4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
   5. Nickel chrome 80/20 heating elements.
   6. Airflow switch for proof of airflow.
   7. Fan interlock contacts.
   8. Silent magnetic contactor for each step of control.

I. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
   1. Control Transformer: Factory mounted for control voltage required for DDC controller. DDC controller provided by BAS manufacturer for factory installation.
   2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
   3. Disconnect Switch: Factory-mounted, fuse type.

J. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

K. Electronic Direct Digital Controls: Provided by Building Automation System manufacturer. Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices are specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:
   1. Damper Actuator: 24 V, powered closed, powered open.
   2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
      a. Occupied and unoccupied operating mode.
      b. Remote reset of airflow or temperature set points.
      c. Room Sensor: Wall mounted with temperature set-point adjustment, tenant override pushbutton, and access for connection of portable operator terminal.
      d. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."

L. Control Sequence:
   1. Occupied (Primary Airflow On):
      a. Operate as throttling control for cooling.
      b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps.

2. Unoccupied (Primary Airflow Off):
   a. When pressure at primary inlet is zero or less, fan is de-energized.
   b. As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps.

2.3 HANGERS AND SUPPORTS

A. Hanger Rods: Electrogalvanized, all-thread rods or galvanized rods.

B. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

C. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted temperature sensors.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.
D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.
B. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."
C. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
D. Tests and Inspections:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
E. Air terminal unit will be considered defective if it does not pass tests and inspections.
F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

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

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION
SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Diffusers.

B. Related Sections:
   1. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-
      control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and
      performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location,
      quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items
   are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers,
      access panels, and special moldings.
   5. Duct access panels.

C. Source quality-control reports.

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 manufacturers specified.
      a. Krueger.
b. Nailor Industries of Texas Inc.
c. Price Industries.
d. Titus.

2.2 DIFFUSERS, GRILLES AND REGISTERS

A. Diffusers, registers, and grilles are scheduled on Drawings.

B. Refer to schedule for color, material. Where not specified, coordinate color with Architect prior to ordering.

C. Diffusers, registers, and grilles shall be provided with border type for installation to match ceiling system type.

2.3 SOURCE QUALITY CONTROL AND QUALITY ASSURANCE

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

B. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."


D. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION
SECTION 237400
PACKAGED ROOFTOP UNITS

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 SYSTEM DESCRIPTION

A. The single packaged units shall be designed for outdoor installation and factory assembled as a single package in an ISO 9001 certified facility. Units shall be designed for installation on a roof curb. Units shall be self-contained and assembled on full perimeter base rails allowing for 3-way forklift access and overhead rigging.

B. The single packaged units shall have built-in field-convertible duct connections for down discharge supply/return or horizontal discharge supply/return as shown and be available with factory installed options or field installed accessories. The units shall be factory piped, wired, charged with HFC-410a refrigerant and factory tested prior to shipment. All unit wiring shall be both numbered and color coded. Cooling performance shall be rated in accordance with DOE and ARI test procedures. Units shall be CSA certified to ANSI Z21.47 and UL 1995/CAN/CSA No. 236-M90 standards.

1.3 SUMMARY

A. This Section includes packaged rooftop units with the following design intent:

1. Single Zone VAV packaged RTU with Economizer.
2. Variable Volume packaged RTU with Barometric Exhaust Economizer.

1.4 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

B. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply Air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

C. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
1.5 **ACTION SUBMITTALS**

A. **Product Data:** Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. **Shop Drawings:**
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.

1.6 **CLOSEOUT SUBMITTALS**

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

1.7 **MAINTENANCE MATERIAL SUBMITTALS**

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. Fan Belts: One set for each belt-driven fan.
   2. Filters: One set of filters for each unit.

1.8 **QUALITY ASSURANCE**

A. **ARI Compliance:**
   1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
   2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. **ASHRAE Compliance:**
   1. Comply with ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.
   2. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

C. **UL Compliance:** Comply with UL 1995.

D. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 **WARRANTY**

A. **General Warranty:** The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
B. Special Warranty: Manufacturer shall warrant rooftop units agreeing to replace (parts and labor) components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Five (5) years from date of Substantial Completion.
2. Warranty Period for Gas Heat Exchangers: Ten (10) years from date of Substantial Completion.
3. Warranty Period for Other Parts: One (1) year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. AAON, Inc.
2. Diakin Corporation
5. Lennox Industries Inc.
6. Trane.

2.2 VAV PACKAGED ROOFTOP UNIT WITH ECONOMIZER

A. General

1. The units shall be fully factory assembled, pre-tested, single piece heating and cooling unit. Contained within the unit enclosure shall be all factory wiring, piping, controls.

B. Unit Cabinet

1. Unit cabinet shall be constructed of galvanized steel, with exterior surfaces coated with a non-chalking, powdered paint finish, certified at 1000 hours salt spray test per ASTMB117 standards. Indoor blower section shall be insulated with a minimum ½ inch thick insulation, coated on the airside. Aluminum foil faced insulation shall be used in the furnace compartment and be fastened with ridged fasteners to prevent insulation from entering the air stream. Cabinet panels shall be removable for servicing and maintenance. Full perimeter base rails shall be provided to assure reliable transit of equipment, overhead rigging and proper sealing on roof curb applications.
2. Units are suitable for either bottom or horizontal duct connections.
3. 2 inch MERV 8 filters shall be furnished and be accessible through a hinged access door, sealed airtight. Fan performance measuring ports shall be provided on the outside of the cabinet to allow accurate air measurements of evaporator fan performance without removing panels or creating air by-pass of the coils.
4. Stainless steel condensate pan shall be internally sloped and conform to ASHRAE 62-89 self-draining standards. Condensate connection shall be a minimum of ¾ inch I.D. female and be a ridged mount connection.

C. Supply Fan Assembly

1. Unit shall utilize a plenum fan design for pressurization of unit supply air plenum. Fan shall be a direct drive or belt drive assembly with an adjustable pitch motor pulley. Fan
wheel shall be dynamically balanced to operate smoothly throughout the entire range of operation. Bearings shall be sealed and permanently lubricated.

2. Unit to be equipped with Variable Speed Drive (VFD) for supply fan operation. VFD to allow supply fan RPM to vary based on number of compressors or heating stages energized.

D. Condenser Fan Assembly

1. The condenser fans shall be a direct drive assembly, discharging air vertically. Fan shall be propeller type, dynamically balanced for smooth operation. Fan motor shall be totally enclosed and internally protected against overload conditions and staged independently. Bearings shall be sealed with permanently lubricated. They shall be dynamically balanced.

E. Refrigeration Components

1. Compressors:
   a. Fully hermetic type with internal high pressure and temperature protection.
   b. Shall have internal spring isolation and sound muffling to minimize vibration and noise, and be externally isolated on a dedicated, independent mounting.

2. Evaporator and Condenser Coils
   a. Aluminum plate fins mechanically bonded to seamless internally enhanced copper tubes with brazed joints.
   b. Direct expansion, draw-thru design.

3. Refrigerant Circuit and Refrigerant Safety Components
   a. Independent fixed-orifice or thermal expansion device
   b. Liquid line filter drier/strainer
   c. Accessible service gage connections on both suction and discharge lines to charge, evacuate, and measure refrigerant pressure during any necessary servicing or troubleshooting, without losing charge.
   d. The 6-1/2 through 12-1/2 ton unit shall have two independent refrigerant circuits, equally split in 50% capacity increments. Units larger than 12-1/2 tons to have four independent refrigerant circuits.
   e. Hot gas bypass on lead refrigerant circuit to provide cooling in low load application.

F. Filter Section

1. Standard filter section shall consist of 2 inch MERV 8 pleated filters installed

G. Gas Heating Section

1. Provide induced draft combustion with post-purge logic, energy saving direct spark ignition, and redundant main gas valve. The heat exchanger shall be of the tubular type, constructed of T1-40 aluminized steel for corrosion resistance and allowing minimum mixed air entering temperature of 25°F. Burners shall be of the in-shot type, constructed of aluminum coated steel and contain air mixture adjustments. All gas piping shall enter the unit cabinet at a single location through either the side or curb without any field modifications. Integrated control boards shall provide timed control of evaporator fan functioning and burner ignition. Heating section shall be provided with the following minimum protection.
   a. Primary and auxiliary high-temperature limit switches.
   b. Induced draft pressure sensor.
   c. Flame roll out switch (manual reset).
d. Flame proving controls.

e. At least 2 stages of capacity control.

H. Electrical Requirements

1. All unit power wiring shall enter unit cabinet at a single factory-provided location and be capable of side or bottom entry. Separate side and bottom openings shall be provided for the control wiring.

2. Provide unit with a disconnect switch. VFD may be disconnecting means.

I. Controls

1. Factory Installed and Factory Provided Controller

   a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of stand-alone operation with unit configuration, set point adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.

   b. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.

   c. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.

   d. Multiple-Zone Variable Air Volume Controller

      1. Unit shall utilize a variable capacity compressor system and a variable speed supply fan system to modulate cooling and airflow as required to meet space temperature cooling loads and to save operating energy. Supply fan speed shall modulate based on supply air duct static pressure. Cooling capacity shall modulate based on supply air temperature.

      2. All sensors required for proper unit operation to be provided by unit manufacturer for installation and wiring in field.

      3. Unit configuration, set point adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen.

   e. Single-Zone Variable Air Volume Controller

      1. Unit shall utilize a variable capacity compressor system and a variable speed supply fan system to modulate cooling and airflow as required to meet space temperature cooling loads and to save operating energy. Supply fan speed shall modulate based on supply air temperature. Cooling capacity shall modulate based on supply air temperature.

      2. All sensors required for proper unit operation to be provided by unit manufacturer for installation and wiring in field.

      3. Unit configuration, set point adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen.

2. Controls shall include the following:

   a. Self-contained low-voltage control circuit protected by a circuit breaker on the 24-volt transformer side.

   b. Lockout circuit to provide reset capability at the space thermostat should any of the following standard safety devices trip and shut off compressor.

      1) Loss-of-charge/Low-pressure switch.

      2) High-pressure switch.

      3) Freeze-protection thermostat (evaporator coil)
c. Automatically-resetting compressor over temperature and over current protection.
d. Low voltage terminal strip for easy hook-up to a thermostat
e. Independent monitoring of each refrigerant safety switch
f. Anti-short cycle protection

3. Standard Terminal Block
   a. Unit shall be provided with a terminal block for field installation of programmable thermostat.
   b. Provide 7 day programmable thermostat with occupancy override.

J. Factory Installed Options
1. Economizer (fixed dry bulb): When the outdoor air temperature is greater than 65 °F, economizer operation shall be locked out. Interlocked outdoor air and return air dampers positioned by a fully-modulating spring-return damper actuator. The maximum leakage rate for the outdoor air dampers shall not exceed 3% at a pressure differential of ½ inch w.g. Dampers can be adjusted for the minimum outside air requirement with a unit-mounted potentiometer. During economizer operation, the outside air and return air dampers shall modulate to maintain the space temperature set point. An outdoor air rain hood with water eliminator shall be provided. Dampers close when the supply fan motor is de-energized or when power is lost.
2. Phase monitor: Monitor will shut the unit down in an out of phase condition
3. Condenser Coil Hail Guard
4. Convenience Outlet: 120 volt non-powered convenience outlet.

2.4 ROOF CURBS

A. Standard Roof Curbs
1. The curb shall bear directly on the roof structure and shall be flashed and waterproofed into the roof’s membrane waterproofing system by the installing contractor.
2. The curb shall be constructed from a minimum of 16 ga G90 galvanized perimeter steel with a factory attached wood nailer. The perimeter steel seams shall be continuously welded.
3. The curb shall have factory installed lifting points
4. Curbs to be internally insulated with at least 1-1/2 inch insulation.
5. The curb section shall be complete with factory installed duct supports.
6. The curb shall be constructed to match the pitch of the roof.
7. There shall also be a continuous closed cell sponge material above the top of the curb to provide a waterproof seal between the rooftop unit.
8. Where size prohibits one piece shipping, the isolation curb shall be split into a minimum number of sections and all connecting hardware shall be supplied by the manufacture.
9. All installation hardware shall be provided by the curb manufacturer.
10. Height of curb to be 14”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in separate specification. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest approved drain.

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

C. Duct installation requirements are specified in separate specification. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors.
4. Install return-air duct continuously through roof structure.

3.4 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. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
B. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION
DEDICATED OUTSIDE AIR SYSTEMS

1.00 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following equipment:
   1. Dedicated outside air systems (DOAS).

1.03 DEFINITIONS

A. BAS: Building Automation System.

1.04 SUBMITTALS

A. Product Data: Include manufacturer’s technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Wiring Diagrams: Power, signal, and control wiring.

D. On-Board Controller: Include detailed technical data for on-board programmable controller, available input and output control points, programmed setpoints, control schematic and sequence of operations.

E. Factory & Field Quality-Control Test Reports.

F. Operation and Maintenance Data: Include emergency, operation, and maintenance manuals.

G. Warranties: Special warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of DOAS. These are based on the Basis of Design system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, “Energy Efficient Design of New Buildings except Low-Rise Residential Buildings” and International Energy Conservation Code, whichever is greater.”
E. ARI Certification: Units shall be ARI certified and listed.

F. ARI Compliance: Rate rooftop air-conditioner capacity according to ARI 340/360, “Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.”


1.06 COORDINATION

A. Coordinate location of existing roof curbs and installation of equipment supports.

1.07 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to replace components of DOAS that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer’s standard, but not less than five (5) years from equipment start-up or 6 months after shipment (whichever comes first).

2. Warranty Period for Heat Exchangers: Manufacturer’s standard, but not less than five (5) years from equipment start-up or 6 months after shipment (whichever comes first).

3. Warranty Period for Control Boards: Manufacturer’s standard, but not less than three (3) years from equipment start-up or 6 months after shipment (whichever comes first).

4. Warranty Period for Variable-Speed Fan Motors: Manufacturer’s standard, but not less than three (3) years from equipment start-up or 6 months after shipment (whichever comes first).

5. Warranty Period for temperature and humidity sensors: Manufacturer’s standard, but not less than three (3) years from equipment start-up or 6 months after shipment (whichever comes first).

1.08 EXTRA MATERIALS

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

1. Fan Belts: One set for each belt-drive fan.

2. Filters: One set of filters for each unit.

2.00 PRODUCTS

2.01 DEDICATED OUTSIDE AIR SYSTEMS (DOAS)

A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified below with no exceptions.

1. Aaon

2. Addison

3. Daikin

4. Engineered Air

5. Munters

6. Desert Aire
B. Description: Factory assembled and tested; designed for exterior installation; consisting of compressor, indoor and outside refrigerant coils, indoor fan and outside coil fan, refrigeration and temperature controls, filters, and dampers.

C. Base and Cabinet:
   1. The unit shall be double wall construction with heavy duty minimum 20 gauge G-90 galvanized steel. Gasketed access doors shall be minimum 20 gauge steel with 2" (R-13) insulation and a 24 gauge galvanized steel liner. Standard outer panels will be insulated with 2" (R-13) insulation with a 24 gauge galvanized steel interior liner. The underside of the base panel shall be insulated with 3/8" closed cell foam insulation. Base pan of the unit shall have no openings or penetrations. The design of the cabinet shall allow access to the compressor and electrical control panel without impairing unit operation.
   2. Cabinet shall be designed for vertical supply air duct connection.
   3. Service access doors shall also be mounted with stainless steel hinges and equipped with 1/4 turn cam operated adjustable compression type latches.
   4. Provide perforated-metal liner knockouts for electrical and piping connections, exterior condensate drain connections and lifting lugs. Knockouts shall be thru unit sidewall.
   5. The condensers shall have a vinyl coated wire coil guard to protect the condensers as well as the compressors.
   6. Paint Finish: polyester urethane powder coat with primer.

D. IAQ Condensate Drain Pan: The condensate drain pan shall be double sloped to comply with ASHRAE Standard 62-1 and shall be fabricated from heavy gauge stainless steel. The bottom of the condensate drain pan shall be insulated with closed cell neoprene insulation. The drain pan shall be furnished with an MPT drain fitting positioned at the exterior of the cabinet. The weight of the coil and other components shall not compress the insulation thus reducing its insulation value. A float switch shall be provided in the condensate drain pan and shall be hardwired to shut down the unit if the switch trips. Condensate float switch alarm shall be generated on the in-built controller and BAS system. The alarm shall stay on until the issue has been resolved.

E. Supply Fan Section:
   1. The standard fan assembly shall be a plenum fan assembly mounted on rubber vibration isolation. The bearings on both the blower shaft and motor shall be permanently lubricated.
   2. The supply fan motor shall be premium efficiency, ODP, and externally protected (manual reset).

F. Variable Frequency Drive (VFD): Manufacturer furnished and wired integral VFD shall modulate supply air fan speed per control sequence. VFD shall be suitable for operation in a 50°C ambient temperature. VFD shall be housed in a NEMA 3R enclosure as a minimum.

G. Condenser Fans and Motors: Condenser fan motors are direct-drive and shall be fitted with permanently lubricated sealed ball bearings protected with shaft mounted rain shields. Condenser fans shall be vertical discharge and shall be constructed with steel spider and formed aluminum blades securely riveted together. Fans shall be statically and dynamically balanced to provide efficient operation.

H. Refrigeration System:
   1. The refrigerant system shall operate with R-410A refrigerant and shall include the compressor, crankcase heater, copper-tube, aluminum finned condenser and evaporator
coils. The refrigerant circuit shall include check valves, filter/drier, high pressure safety control (manual-reset), low pressure control/loss of charge protector (auto-reset), dual gauge connections for high and low pressure readings, thermostat for coil freeze protection during low-ambient temperature operation and thermal expansion valve with adjustable superheat. The condensing section of the unit shall be integral to the unit and shall be manufactured by the air conditioning unit manufacturer.

2. Evaporator and Condenser Coils: Evaporator coil shall be enhanced surface aluminum fins, formed on multiple rows of seamless rifled copper tubing, arranged in staggered tube configuration with galvanized steel header plates. These tubes are mechanically expanded, firmly bonding the tube to the shoulder of each fin.

3. Modulating hot gas reheat coil for precise temperature and humidity control.

I. Compressor(s): hermetically sealed variable capacity, inverter driven scroll compressors, include integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heaters. Compressor shall be warranted by manufacturer for five years from date of installation.

J. Filters: 2-inch (50-mm) thick, fiberglass, pleated, MERV-8, throwaway filters in filter rack.

K. Gas Heating Section

1. Provide induced draft combustion with post-purge logic, energy saving direct spark ignition, and redundant main gas valve. The heat exchanger shall be of the tubular type, constructed of T1-40 aluminized steel for corrosion resistance and allowing minimum mixed air entering temperature of 25°F. Burners shall be of the in-shot type, constructed of aluminum coated steel and contain air mixture adjustments. All gas piping shall enter the unit cabinet at a single location through either the side or curb without any field modifications. Integrated control boards shall provide timed control of evaporator fan functioning and burner ignition. Heating section shall be provided with the following minimum protection.
   a. Primary and auxiliary high-temperature limit switches.
   b. Induced draft pressure sensor.
   c. Flame roll out switch (manual reset).
   d. Flame proving controls.
   e. At least 2 stages of capacity control.

L. Outside-Air Damper: The unit shall be equipped with a factory installed linked damper blades, for 0 to 100 percent outside air, with fully modulating, spring-return damper motor and weatherproof, outside-air intake hood with bird screen.

M. Power Connection: The unit shall be designed for electrical power entry through the side of the cabinet. The starter/control panel shall include a programmable logic controller and a complete modular, integrated motor control system mounted on din rails. All safety and operating controls shall be factory mounted. The system shall also include all relays, fan contactors, compressor contactors, and power distribution. The 24-volt control circuit shall include a transformer and low voltage terminal strip for interface with a control system.

N. Unit Controls: Provide unit with Solid-state programmable logic controller and components contain at least the following features:
   1. Indoor fan on/off delay.
   2. Default control to ensure proper operation after power interruption.
   3. Service relay output.
4. Unit diagnostics and diagnostic code storage.
5. Field-adjustable control parameters.
6. Defrost control.
7. Dehumidification control with dehumidistat.
8. Economizer control.
10. Minimum run time.
11. Low-refrigerant pressure control.

O. Sequence of Operation: Detailed control points and sequence summary can be found on the plans.

P. Expander Board: provide a factory furnished expander board to accommodate additional control points beyond the capability of standard control board.

Q. A factory installed clogged filter indicator shall be mounted to indicate dirty or clogged filters when the preset pressure differential across the filters is reached. The indicator shall be manual-reset and shall include contacts for remote annunciation.

R. DDC Temperature Control: Install stand-alone control module providing link between unit controls and future DDC temperature-control system. Control module shall be open protocol and shall be BACnet compatible.

S. Automatic Unit Restart: In the case of a power failure, the unit shall have the capability to start back up with the last retained control set points. This auto restart applies to equipment controls, VFD, fan and compressors.

T. Service Outlets: Two (2) 115-V, ground-fault, circuit-interrupter type shall be provided with the unit. A 115 Volt ground-fault, circuit-interrupter (GFCI) convenience outlet receptacle shall be factory installed. It is furnished with a 15A circuit breaker. Contractor shall be responsible for providing a separate 115 volt power and ground for the circuit.

U. Roof Curb: Manufacturer to provide 14" tall roof curb, shipped with unit from factory.

2.02 MOTORS

A. General requirements for motors are specified in Section 23 05 13 “Common Motor Requirements for HVAC.”

B. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Controllers, electrical devices, and wiring are specified in Division 26 Sections.

2.03 ROOF CURBS

A. Standard Roof Curbs
   1. The curb shall bear directly on the roof structure and shall be flashed and waterproofed into the roof's membrane waterproofing system by the installing contractor.
   2. The curb shall be constructed from a minimum of 16 ga G90 galvanized perimeter steel with a factory attached wood nailer. The perimeter steel seams shall be continuously welded.
3. The curb shall have factory installed lifting points.
4. Curbs to be internally insulated with at least 1-1/2 inch insulation.
5. The curb section shall be complete with factory installed duct supports.
6. The curb shall be constructed to match the pitch of the roof.
7. There shall also be a continuous closed cell sponge material above the top of the curb to provide a waterproof seal between the rooftop unit.
8. Where size prohibits one piece shipping, the isolation curb shall be split into a minimum number of sections and all connecting hardware shall be supplied by the manufacturer.
9. All installation hardware shall be provided by the curb manufacturer.
10. Height of curb to be 18”.

3.00 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb, maintaining manufacturer’s recommended clearances.
B. Unit Support: Install unit level on curb provided from factory. Coordinate penetrations and flashing with roof construction. Secure units to structural support with anchor bolt.

3.02 CONNECTIONS

A. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts.
B. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.
C. Ground equipment according to Division 26.
D. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 FIELD QUALITY CONTROL

A. 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. Remove malfunctioning units, replace with new units, and retest as specified above.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
B. Complete installation and startup checks according to manufacturer’s written instructions and do the following:
   1. Inspect for visible damage to unit casing.
   2. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
   3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Clean outside coil and inspect for construction debris.
10. Lubricate bearings on fan.
11. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
12. Adjust fan belts to proper alignment and tension.
13. Start unit according to manufacturer’s written instructions.
   a. Start refrigeration system in summer only.
   b. Complete startup sheets and attach copy with Contractor’s startup report.
15. Operate unit for an initial period as recommended or required by manufacturer.
17. Adjust and inspect high-temperature limits.
18. Inspect outside-air dampers for proper stroke.
19. Start refrigeration system and measure and record the following:
   a. Coil leaving-air, dry- and wet-bulb temperatures.
   b. Outside-air, dry-bulb temperature.
20. Inspect controls for correct sequencing of heating, refrigeration, and normal and emergency shutdown.
22. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.05 ADJUSTING

A. Adjust initial temperature and humidity set points.
B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

END OF SECTION
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 complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, concealed, floor-mounted units for ducting.
3. Indoor, exposed, wall-mounted units.
4. Indoor, recessed, ceiling-mounted units.
5. Indoor, suspended, ceiling-mounted units.
6. Indoor, hydronic heat exchangers.
7. Outdoor, air-source heat recovery units.
8. Heat recovery control units.
10. System refrigerant and oil.
11. System condensate drain piping.
12. System refrigerant piping.
13. Metal hangers and supports.
14. Metal framing systems.
15. Fastener systems.
16. Pipe stands.
17. Miscellaneous support materials.
18. Piping and tubing insulation.
19. System control cable and raceways.

1.3 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

C. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.
D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

E. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

F. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

G. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.

H. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units and for HRCUs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
   4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
   5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit control.
   6. Include description of control software features.
   7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
   8. Include refrigerant type and data sheets showing compliance with requirements indicated.
   9. For system design software.
   10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.
   1. Include plans and mounting details.
   2. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
   3. Include diagrams for power, signal, and control wiring.
C. Delegated-Design Submittals:
   1. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
   2. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
   3. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
      a. Retain copies of Installer certificates on-site and make available on request.
   2. For VRF HVAC system manufacturer.
   3. For VRF HVAC system provider.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

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. Filters:
      a. One set for each unit with replaceable filters.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.

3. VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.

4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.

5. Having full-time in-house employees for the following:

   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing, and quality control.
   d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
   e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

   1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
   2. In-place facility located within 120 miles of Project.
   3. Demonstrated past experience with products being installed for period within two consecutive years before time of bid.
   4. Demonstrated past experience on five projects of similar complexity, scope, and value.

   a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.

6. Service and maintenance staff assigned to support Project during warranty period.

7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.

8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

   1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
   2. Installer certification shall be valid and current for duration of Project.
   3. Retain copies of Installer certificates on-site and make available on request.
   4. Each person assigned to Project shall have demonstrated past experience.

   a. Demonstrated past experience with products being installed for period within two consecutive years before time of bid.
   b. Demonstrated past experience on five projects of similar complexity, scope, and value.

5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.
1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
   1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
   2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

   1. Failures include, but are not limited to, the following:
      a. Structural failures.
      b. Faulty operation.
      c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

   2. Warranty Period:
      a. For Compressor: Five year(s) from date of Substantial Completion.
      b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
      c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   1. Daikin AC (Americas), Inc.
   2. LG Electronics.
   3. Mitsubishi Electric & Electronics USA, Inc.
   4. Samsung HVAC.
B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.
4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe or three-pipe system design.
2. System(s) operation, heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional specialist, as defined in Section 01 40 00 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.
   a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
   b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:
a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

4. System Controls:
   a. Network arrangement.
   b. Network interface with other building systems.
   c. Product selection.
   d. Sizing.

B. Service Access:
   1. Provide and document service access requirements.
   2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
   3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
   4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
   5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
   6. Comply with OSHA regulations.

C. System Design and Installation Requirements:
   1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
   2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.
   1. Future changes to system(s) indicated on Drawings.
   2. Each branch circuit shall accommodate addition of one indoor unit(s) with unit capacity equal to average indoor unit connected to the branch circuit.
   3. Each branch circuit shall accommodate deletion of one indoor unit(s) with unit capacity equal to largest indoor unit connected to the branch circuit.

E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:
1. Not less than 50 percent.
2. Not more than 130 percent.
3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to 15 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

I. Outdoor Conditions:
   1. Maximum System Operating Outdoor Temperature: 17°F.
   2. Minimum System Operating Outdoor Temperature: 110°F.

J. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:
   1. Material: Galvanized or painted steel.
   2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
   3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
   4. Mounting: Manufacturer-designed provisions for field installation.
   5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:
   1. Coil Casing: Aluminum, galvanized, or stainless steel.
   2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
   3. Coil Tubes: Copper, of diameter and thickness required by performance.
   4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
   5. Unit Internal Tubing: Copper tubing with brazed joints.
   6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   7. Field Piping Connections: Manufacturer's standard.
   8. Factory Charge: Dehydrated air or nitrogen.
   9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:
   1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
   2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
   3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:
1. Fan(s):
   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
   d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:
1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.
3. Media:
   a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:
1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
   a. Unit inlet air temperature.
   b. Coil entering refrigerant temperature.
   c. Coil leaving refrigerant temperature.
4. Features and Functions:
   a. Self-diagnostics.
   b. Time delay.
   c. Auto-restart.
   d. External static pressure control.
   e. Auto operation mode.
   f. Manual operation mode.
   g. Filter service notification.
   h. Power consumption display.
   i. Drain assembly high water level safety shutdown and notification.
   j. Run test switch.
5. Communication: Network communication with other indoor and outdoor units.
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:
   1. Enclosure: Metal, suitable for indoor locations.
   2. Field Connection: Single point connection to power unit and integral controls.
   4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
   5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.5 INDOOR, CONCEALED, FLOOR-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:
   1. Material: Galvanized or painted steel.
   2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
   3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
   4. Mounting: Manufacturer-designed provisions for field installation.
   5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:
   1. Coil Casing: Aluminum, galvanized, or stainless steel.
   2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
   3. Coil Tubes: Copper, of diameter and thickness required by performance.
   4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
   5. Unit Internal Tubing: Copper tubing with brazed joints.
   6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   7. Field Piping Connections: Manufacturer's standard.
   8. Factory Charge: Dehydrated air or nitrogen.
   9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:
   1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
   2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
   3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:
   1. Fan(s):
a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Materials: Non-ferrous components or ferrous components with corrosion resistant finish.
d. Statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:
1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.
3. Media:
   a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:
1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
   a. Unit inlet air temperature.
   b. Coil entering refrigerant temperature.
   c. Coil leaving refrigerant temperature.
4. Features and Functions:
   a. Self-diagnostics.
   b. Time delay, auto-restart.
   c. External static pressure control.
   d. Auto operation mode.
   e. Manual operation mode.
   f. Filter service notification.
   g. Power consumption display.
   h. Drain assembly high water level safety shutdown and notification.
   i. Run test switch.
5. Communication: Network communication with other indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
I. Unit Electrical:
   1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
   2. Field Connection: Single point connection to power unit and integral controls.
   4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
   5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.6 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:
   1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
   2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
   3. Mounting: Manufacturer-designed provisions for field installation.
   4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:
   1. Coil Casing: Aluminum, galvanized, or stainless steel.
   2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
   3. Coil Tubes: Copper, of diameter and thickness required by performance.
   4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
   5. Unit Internal Tubing: Copper tubing with brazed joints.
   6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   7. Field Piping Connections: Manufacturer's standard.
   8. Factory Charge: Dehydrated air or nitrogen.
   9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:
   1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
   3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:
   1. Fan(s):
      a. Direct-drive arrangement.
      b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:
1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.

G. Grille Assembly: Manufacturer's standard discharge grille mounted in top or front face of unit cabinet.

H. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature, Coil entering refrigerant temperature, Coil leaving refrigerant temperature.
4. Communication: Network communication with other indoor units and outdoor unit(s).
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.7 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
B. Cabinet:
1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:
1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:
1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:
1. Fan(s):
   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
   d. Wheels statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:
1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.
3. Media:
a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.
   1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.
      a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
      b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
   2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
   3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:
   1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
   2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

K. Unit Controls:
   1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
   2. Factory-Installed Controller: Configurable digital control.
   3. Factory-Installed Sensors: Unit inlet air temperature, Coil entering refrigerant temperature, Coil leaving refrigerant temperature.
   4. Communication: Network communication with other indoor units and outdoor unit(s).
   5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
   6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:
   1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
   2. Field Connection: Single point connection to power entire unit and integral controls.
   3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
   4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
   5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
   6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.
2.8 INDOOR, SUSPENDED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:
   1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
   2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
   3. Mounting: Manufacturer-designed provisions for field installation.
   4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:
   1. Coil Casing: Aluminum, galvanized, or stainless steel.
   2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
   3. Coil Tubes: Copper, of diameter and thickness required by performance.
   4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
   5. Internal Tubing: Copper tubing with brazed joints.
   6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   7. Field Piping Connections: Manufacturer's standard.
   8. Factory Charge: Dehydrated air or nitrogen.
   9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:
   1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
      a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
   3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:
   1. Fan(s):
      a. Direct-drive arrangement.
      b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
      c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
      d. Wheels statically and dynamically balanced.
   2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
   4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
   5. Vibration Control: Integral isolation to dampen vibration transmission.
F. Filter Assembly:
   1. Access: Front, to accommodate filter replacement without the need for tools.
   2. Efficiency: ASHRAE 52.2, MERV 7.

G. Discharge-Air Grille Assembly: Mounted in front of unit cabinet.
   1. Discharge Pattern: One-way throw.
   2. Discharge Pattern Adjustment: Field-adjustable limits for range of pattern.
   3. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.

H. Return-Air Grille Assembly: Manufacturer's standard.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:
   1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
   2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

K. Unit Controls:
   1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
   2. Factory-Installed Controller: Configurable digital control.
   3. Factory-Installed Sensors: Unit inlet air temperature, Coil entering refrigerant temperature, Coil leaving refrigerant temperature.
   4. Communication: Network communication with other indoor units and outdoor unit(s).
   5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
   6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:
   1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
   2. Field Connection: Single point connection to power entire unit and integral controls.
   3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
   4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
   5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
   6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.9 OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
   1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.
   a. Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.

3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.

2. Protection: Integral protection against the following:
   a. High refrigerant pressure.
   b. Low oil level.
   c. High oil temperature.
   d. Thermal and overload.
   e. Voltage fluctuations.
   f. Phase failure and phase reversal.
   g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.


5. Oil management system to ensure safe and proper lubrication over entire operating range.

6. Crankcase heaters with integral control to maintain safe operating temperature.

7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:
   a. Casing: Aluminum, galvanized, or stainless steel.
   b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
   c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:
   b. Single- or multiple-pass arrangement.
   c. Construct fins, tubes, and header manifolds of aluminum alloy.
3. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.
   a. Direct-drive arrangement.
   b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
   c. Dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
5. Speed Settings and Control: Variable speed with a speed range of at least 75 percent.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
   a. Refrigerant suction temperature.
   b. Refrigerant discharge temperature.
   c. Outdoor air temperature.
   d. Refrigerant high pressure.
   e. Refrigerant low pressure.
   f. Oil level.
4. Communication: Network communication with indoor units and other outdoor unit(s).
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.
I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 1000 hours according ASTM B 117.

J. Unit Piping:
   1. Unit Tubing: Copper tubing with brazed joints.
   2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   3. Field Piping Connections: Manufacturer's standard.
   4. Factory Charge: Dehydrated air or nitrogen.
   5. Testing: Factory pressure tested and verified to be without leaks.

2.10 HEAT RECOVERY CONTROL UNITS (HRCUs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
   1. Specially designed for use in systems with simultaneous heating and cooling.
   2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

B. Cabinet:
   2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
   3. Mounting: Manufacturer-designed provisions for field installation.
   4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:
   1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
   2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
   3. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
   4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
   5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.
      a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
4. Communication: Network communication with indoor units and outdoor unit(s).
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.11 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
   a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
   b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
   c. Integration shall include monitoring, scheduling, and change of value notifications.
4. Operator Interface:
   a. Operators shall interface with system and unit controls through the following:
      1) Operator interfaces integral to controllers.
      2) Owner-furnished PC connected to central controller(s).
      3) Web interface through web browser software.
4) Integration with Building Automation System.

b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

1) On/off control.
2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English.
10. Supports Imperial and Metric Temperature Units: Fahrenheit.
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
   a. Include multiple interconnected controllers as required.
2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
   a. Sets schedule for daily, weekly, and annual events.
b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English.
4. Temperature Units: Fahrenheit.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
8. Temperature Display: 1-degree increments.
10. Fan Speed Setting: Select between available options furnished with the unit.
11. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
12. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
13. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
15. Service Notification Display: "Filter".
17. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
18. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
19. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
20. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.12 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.13 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B 88, Type L or Type DWV according to ASTM B 306.

2.14 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 23 23 00 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping:

1. Copper Tube: ASTM B 280, Type ACR.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Refrigerant Tubing Kits:

1. Furnished by VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
3. Standard one-piece length for connecting to indoor units.
4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
5. Factory Charge nitrogen.

D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

E. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.
2.15 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel.

2.16 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-line, an Eaton business.
      b. Flex-Strut Inc.
      c. G-Strut.
      d. Unistrut; Part of Atkore International.
   2. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
   4. Channels: Continuous slotted steel channel with turned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   8. Plastic Coating for Use Outdoors: PVC.

2.17 PIPE STANDS

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

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

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

E. High-Type, Multiple-Pipe Stand:
   1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   2. Bases: One or more; plastic.
   3. Vertical Members: Two or more protective-coated-steel channels.
   4. Horizontal Member: Protective-coated-steel channel.
   5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.18 MISCELLANEOUS SUPPORT MATERIALS

A. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.

B. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.19 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 23 07 19 "HVAC Piping Insulation" for system piping insulation requirements.

B. Refrigerant Tubing Insulation and Jacket Requirements:
   1. Flexible Elastomeric Insulation:
      a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C 534, Type I for tubular materials.
      b. Indoors: 1 inch thick.
      c. Outdoors: 1 inch thick.
   2. Field-Applied Jacket:
      a. Concealed: None required.
      b. Indoors, Exposed to View: PVC, color selected by Architect, 20 mils thick.
      c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick.

C. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

D. PVC Jacket Adhesive: Compatible with PVC jacket.
E. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.20 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
   a. Flame Travel Distance: 60 inches or less.
   b. Peak Optical Smoke Density: 0.5 or less.
   c. Average Optical Smoke Density: 0.15 or less.

2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.
   a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
   b. PVC insulation.
   c. Braided or foil shielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1685.

2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
   b. PVC insulation.
   c. Braided or foil shielded.
   d. PVC jacket.
   e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.
   a. Paired, one pair, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. PVC insulation.
   c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1685.

2. Plenum-Rated Cable: NFPA 70, Type CMP.
   a. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. Fluorinated ethylene propylene insulation.
   c. Unshielded.
   d. Fluorinated ethylene propylene jacket.
   e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.

   1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
   2. Conductors: 100-ohm, 23 AWG solid copper.
   4. Cable Rating: By application.
   5. Jacket: Blue thermoplastic.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.21 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:
   1. Maintain manufacturer's recommended clearances for service and maintenance.
   2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
   1. Loose components shall be installed by system Installer under supervision of manufacturer's service representative.

C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.

H. Attachment: Install hardware for proper attachment to supported equipment.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.
B. Install outdoor units on support structures indicated on Drawings.

C. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 07 72 00 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

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

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.

2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.

3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

   a. Details indicated on Drawings.
b. Manufacturer's requirements.
c. Governing codes.
d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.

5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:
   1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:
   1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:
   1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
   2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 1/4 inch.
   3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 13 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

G. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
   1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

H. When brazing, remove or protect components that could be damaged by heat.

I. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

J. Joint Construction:
   1. Ream ends of tubes and remove burrs.
   2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
      a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
      b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

B. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Comply with MFMA-103 for metal framing system selections and applications that are not specified.

E. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 "Roof Accessories" for curbs.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Building attachments shall be attached to structural steel.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Piping and Tubing Insulation:
   1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   2. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

M. Horizontal-Piping Hangers and Supports: Install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
   4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
   5. Pipe stands for horizontal pipes located outdoors.
   6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
   7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
   1. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

O. Vertical-Piping Clamps: Install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8).
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.

P. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet.

Q. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.

R. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.

S. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

T. Trim excess length of continuous-thread hanger and support rods to 1 inch.
U. Hanger-Rod Attachments: Install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

V. Building Attachments: Install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF PIPING AND TUBING INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

### 3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.

B. Comply with requirements for metal ducts specified in Section 23 31 13 "Metal Ducts."

C. Comply with requirements for nonmetal ducts specified in Section 23 31 16 "Nonmetal Ducts."

D. Comply with requirements for air duct accessories specified in Section 23 33 00 "Air Duct Accessories."

E. Comply with requirements for air diffusers specified in Section 23 37 13.13 "Air Diffusers."

F. Comply with requirements for registers and grilles specified in Section 23 37 13.23 "Registers and Grilles."

### 3.11 ELECTRICAL INSTALLATION

A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.

B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.

1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.

C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.

D. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
E. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" for grounding connections.

F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
   2. Locate nameplate or label where easily visible.

G. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.
   1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
   2. Outlet boxes for cables shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
   3. Flexible metal conduit shall not be used.

H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

I. Install manufactured conduit sweeps and long-radius elbows if possible.

J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

A. Cybersecurity:
   1. Software:
      a. Coordinate security requirements with IT department.
      b. Ensure that latest stable software release is installed and properly operating.
      c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
   2. Hardware:
      a. Coordinate location and access requirements with IT department.
      b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
      c. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.
B. Installation Method:

1. Install cables in raceways except as follows:
   a. Within equipment and associated control enclosures.
   b. In accessible ceiling spaces where open cable installation method may be used.
   c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than [30 inches] <Insert dimension> apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

A. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by a factory-trained and authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

   a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
   a. First Visit: Kick-off meeting.
   b. Second Visit: At approximately 25 percent completion of system(s).
   c. Third Visit: At approximately 50 percent completion of system(s).
   d. Fourth Visit: At approximately 75 percent completion of system(s).
   e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:
   a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
   b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
   c. Meeting shall cover the following as a minimum requirement:
      1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
      2) Manufacturer's installation requirements specific to systems being installed.
      3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
      4) Required field activities related installation of VRF HVAC system.
      5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:
   a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
   b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
   c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
   d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
   e. Issue a report for each visit, documenting the visit.
      1) Report to include name and contact information of individual making the visit.
      2) Date(s) and time frames while on-site.
      3) Names and contact information of people meeting with while on-site.
      4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:
a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
d. Inspection reports for indoor units shall include, but not be limited to, the following:

   1) Unit designation on Drawings.
   2) Manufacturer model number.
   3) Serial number.
   4) Network address, if applicable.
   5) Each equipment setting.
   6) Mounting, supports, and restraints properly installed.
   7) Proper service clearance provided.
   8) Wiring and power connections correct.
   9) Line-voltage reading(s) within acceptable range.
  10) Wiring and controls connections correct.
  11) Low-voltage reading(s) within an acceptable range.
  12) Controller type and model controlling unit.
  13) Controller location.
  14) Temperature settings and readings within an acceptable range.
  15) Humidity settings and readings within an acceptable range.
  16) Condensate removal acceptable.
  17) Fan settings and readings within an acceptable range.
  18) Unit airflow direction within an acceptable range.
  19) If applicable, fan external static pressure setting.
  20) Filter type and condition acceptable.
  21) Noise level within an acceptable range.
  22) Refrigerant piping properly connected and insulated.
  23) Condensate drain piping properly connected and insulated.
  24) If applicable, ductwork properly connected.
  25) If applicable, external interlocks properly connected.
  26) Remarks.

e. Inspection reports for outdoor units shall include, but not be limited to, the following:

   1) Unit designation on Drawings.
   2) Manufacturer model number.
   3) Serial number.
   4) Network address, if applicable.
   5) Each equipment setting.
   6) Mounting, supports, and restraints properly installed.
   7) Proper service clearance provided.
   8) Wiring and power connections correct.
   9) Line-voltage reading(s) within acceptable range.
  10) Wiring and controls connections correct.
  11) Low-voltage reading(s) within an acceptable range.
  12) Condensate removal acceptable.
  13) Noise level within an acceptable range.
  14) Refrigerant piping properly connected and insulated.
  15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Refrigerant piping properly connected and insulated.
22) Condensate drain piping properly connected and insulated.
23) Automatic dampers properly installed and operating.
24) Ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

g. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity readings.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Fan external static pressure setting.
19) Filter type and condition acceptable.
20) Noise level within an acceptable range.
21) Automatic dampers properly installed and operating.
22) Ductwork properly connected.
23) If applicable, external interlocks properly connected.
24) Remarks.

h. Inspection reports for hydronic units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Condensate removal acceptable.
16) Noise level within an acceptable range.
17) Refrigerant piping properly connected and insulated.
18) Hydronic piping properly connected and insulated.
19) Proof of water flow checked for proper operation.
20) Condensate drain piping properly connected and insulated.
21) If applicable, external interlocks properly connected.
22) Remarks.

i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.

j. Installer shall correct observed deficiencies found by the inspection.

k. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.

l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.

m. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
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 motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:
1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.

2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.

3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.

4. Prepare test report to record the following information for each test:
   
   a. Name of person starting test, company name, phone number, and e-mail address.
   b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
   c. Detailed description of extent of tubing tested.
   d. Date and time at start of test.
   e. Test pressure at start of test.
   f. Outdoor temperature at start of test.
   g. Name of person ending test, company name, phone number, and e-mail address.
   h. Date and time at end of test.
   i. Test pressure at end of test.
   j. Outdoor temperature at end of test.
   k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.

2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.

3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.

4. Prepare test report to record the following information for each test:
   
   a. Name of person starting test, company name, phone number, and e-mail address.
   b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
   c. Detailed description of extent of tubing tested.
   d. Date and time at start of test.
   e. Test pressure at start of test.
   f. Outdoor temperature at start of test.
   g. Name of person ending test, company name, phone number, and e-mail address.
   h. Date and time at end of test.
   i. Test pressure at end of test.
   j. Outdoor temperature at end of test.
   k. Remarks:

5. Submit test reports for Project record.

6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer’s service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect, Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.
3.19 ADJUSTING
A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.
B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

3.20 PROTECTION
A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE
A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT
A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION
A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
B. Instructor:

1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
2. Instructor's credentials shall be submitted for review by Architect before scheduling training.
3. Instructor(s) sole job responsibility shall be Owner training.
4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
5. Perform not less than eight total hours of training.

D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. Training Attendees: Assume three people.

F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.

G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.

H. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

I. Acceptance: Obtain Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 81 29
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Related Requirements:

1. Division 01 Section "Submittal Procedures" for coordinating Division 26 submittals with other Divisions.
2. Division 01 Section "Operation and Maintenance Data" for submitting operation and maintenance manuals.
3. Division 01 Section "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
4. Division 01 Section "Demonstration and Training" for training of Owner's personnel.

1.3 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Engineer's and Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Engineer's and Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

C. File Transfer Protocol (FTP): Communications protocol that enables transfer of files to and from another computer over a network and that serves as the basis for standard Internet protocols. An FTP site is a portion of a network located outside of network firewalls within which internal and external users are able to access files.


1.4 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and Architect and additional time for
handling and reviewing submittals required by those corrections. Inadequate lead times will not be reason for approval of submittal.

1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.

1.5 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Engineer's Digital Data Files: Electronic digital data (AutoCad files and/or Revit models) used to produce the Contract Drawings will be provided by Engineer for Contractor's use in preparing submittals only after Engineer's Release Form has been appropriately executed.

1. Engineer will furnish Contractor one set of digital data files used to produce the Contract Drawings for use in preparing Shop Drawings and Project record drawings.

a. Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to the Contract Drawings.

b. Digital Drawing Software Program: The Contract Drawings are available in Autodesk Revit 2014 and/or AutoCAD 2013.

c. Contractor shall execute a data licensing agreement (Engineer’s Release Form) in substantial agreement with AIA Document C106, Digital Data Licensing Agreement.

d. The Contractor agrees as a pre-condition of the use of Engineer’s digital data files to provide Engineer with Contractor’s final files (Record Drawings) at the completion of the project in the same software version as provided by Engineer.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

2. Submit all submittal items required for Division 26 Sections concurrently unless partial submittals are indicated on approved submittal schedule. Product data submittals and shop drawings may be submitted in separate volumes.

3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.

4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. Engineer and Architect reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

5. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer and Architect will advise Contractor when a submittal being processed must be delayed for coordination.

6. Resubmittal Review: One resubmittal is allowed. Additional resubmittal reviews will be performed after Engineer’s review fees have been negotiated. Allow 15 days for review of each resubmittal.

C. Paper Submittals: Paper submittals are not permitted.

D. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:
1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.

2. Name file with submittal number or other unique identifier, including revision identifier.
   a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-231000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-231000.01.A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer and Architect.

4. Transmittal Form for Electronic Submittals: Use electronic form acceptable to Owner and Architect, containing the following information:
   a. Project name.
   b. Date.
   c. Name and address of Engineer.
   d. Name of Architect.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Names of subcontractor, manufacturer, and supplier.
   h. Category and type of submittal.
   i. Submittal purpose and description.
   j. Specification Section number and title.
   k. Specification paragraph number or drawing designation and generic name for each of multiple items.
   l. Drawing number and detail references, as appropriate.
   m. Location(s) where product is to be installed, as appropriate.
   n. Related physical samples submitted directly.
   o. Indication of full or partial submittal.
   p. Transmittal number, numbered consecutively.
   q. Submittal and transmittal distribution record.
   r. Other necessary identification.
   s. Remarks.

5. Metadata: Include the following information as keywords in the electronic submittal file metadata:
   a. Project name.
   b. Number and title of appropriate Specification Section.
   c. Manufacturer name.
   d. Product name.

6. Options: Clearly identify each option requiring selection by Contractor.

   E. Options: Identify options requiring selection by Engineer.

   F. Deviations and Additional Information: Prepare on Contractor's letterhead, relevant information, requests for data, revisions other than those requested by Engineer on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.
G. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's and Architect's action stamp.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by Division 26 Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Submit electronic submittals via email or directly to Project Web site as PDF electronic files.

2. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.
   a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.

B. Product Data:

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:
   a. Manufacturer's catalog cuts.
   b. Manufacturer's product specifications.
   c. Standard color charts.
   d. Statement of compliance with specified referenced standards.
   e. Testing by recognized testing agency.
   f. Application of testing agency labels and seals.
   g. Notation of coordination requirements.
   h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:
   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
   d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.
1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
   a. Identification of products.
   b. Schedules.
   c. Compliance with specified standards.
   d. Notation of coordination requirements.
   e. Notation of dimensions established by field measurement.
   f. Relationship and attachment to adjoining construction clearly indicated.
   g. Seal and signature of professional engineer if specified.

2. BIM (Revit) File Incorporation: Develop and incorporate Shop Drawing files into Building Information Model established for Project.

D. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
   1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
   2. Manufacturer and product name, and model number if applicable.
   3. Number and name of room or space.
   4. Location within room or space.

E. Coordination Drawing Submittals: Comply with requirements specified in Division 01 Section "Project Management and Coordination."

F. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Closeout Procedures."

G. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."

H. LEED Submittals: Comply with requirements specified in Division 01 sustainable design requirements Section.

I. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.

J. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

K. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

L. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.
M. Product Certificates: Submit written statements on manufacturer’s letterhead certifying that product complies with requirements in the Contract Documents.

N. Material Certificates: Submit written statements on manufacturer’s letterhead certifying that material complies with requirements in the Contract Documents.

O. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency’s standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

P. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

Q. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:

1. Name of evaluation organization.
2. Date of evaluation.
3. Time period when report is in effect.
4. Product and manufacturers’ names.
5. Description of product.
6. Test procedures and results.
7. Limitations of use.

R. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency’s standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

S. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency’s standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

T. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer and Architect.

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01 Section "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date
of Contractor’s approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ENGINEER’S ACTION

A. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or revisions required, and return it. Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action, as follows:

1. Engineer’s Review
   a. No Exceptions Taken: Engineer’s review found no apparent discrepancies between submittal data and requirements of Contract Documents. No further submittal review action required from Contractor.
   b. Accepted as Noted: Engineer’s review found the submittal to be in substantial conformance with the requirements of Contract Documents.
   c. Rejected: Engineer’s review found the submittal to be in non-conformance with the requirements of Contract Documents.

2. Responses required by Contractor:
   a. Confirm: Contractor will review Engineer’s notations on submittal and confirm via written response the information requested by Engineer.
   b. Revise: Contractor will review Engineer’s notations on submittal and revise submittal to comply.
   c. Resubmit: Contractor will make changes to submittal in accordance with Engineer’s notations and resubmit complete section.

3. Additional Requirements:
   a. Requires Review and Approval by _______: In addition to Engineer’s review of submittal, the submittal must be officially submitted and approved by the authority/consultant noted.

B. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Engineer and Architect.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may be returned by the Engineer without action.

END OF SECTION
SECTION 26 05 00

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and other Specification Sections, apply to this and other sections of Division 26.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination drawings.
3. Record documents.
5. Rough-ins.
6. Electrical installations.
7. Cutting and patching.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Section "SUBMITTALS."

B. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.

1. Shop Drawings: 1 additional blue- or black-line prints.
2. Product Data: 1 additional copy of each item.
3. Samples: 1 addition as set.

C. Additional copies may be required by individual sections of these Specifications.

D. Three copies of the Material Safety Data Sheets (MSDS) for each product used in the construction of this project shall be submitted to the Owner in hard backed, three-ring binders as part of the final close-out of the project.

1.4 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Section "PROJECT CLOSEOUT." In addition to these requirements, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Section "PROJECT CLOSEOUT." In addition to these requirements, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.7 WARRANTIES:

A. Refer to the Section: SPECIFIC WARRANTIES for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties specified in Division 26, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

PART 2 - PRODUCTS

(NONE)

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

A. Obtain all permits and pay all fees.
B. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements.

1. Coordinate electrical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensions, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Section "ACCESS DOORS" and Section "BASIC ELECTRICAL MATERIALS AND METHODS."
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
   a. Uncover Work to provide for installation of ill-timed Work.
   b. Remove and replace defective Work.
   c. Remove and replace Work not conforming to requirements of the Contract Documents.
   d. Remove samples of installed Work as specified for testing.
   e. Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

2. Cut, remove and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers’ qualifications refer to the materials and methods required for the surface and building components being patched.
   a. Refer to Section "DEFINITIONS AND STANDARDS" for definition of experienced "Installer."

7. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers’ qualifications refer to the materials and methods required for the surface and building components being patched.
   a. Refer to Section "DEFINITIONS AND STANDARDS" for definition of experienced "Installer."

END OF SECTION
SECTION 26 05 19
WIRE AND CABLES

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 SUBMITTALS
A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE
A. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
   B. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING
A. Deliver wires and cables according to NEMA WC 26.

1.6 COORDINATION
A. Coordinate layout and installation of cables with other installations.
   B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Wires and Cables:
      b. BICC Brand-Rex Company.
      c. Carol Cable Co., Inc.
      d. Senator Wire & Cable Company.
2. Connectors for Wires and Cables:
   a. AMP Incorporated.
   b. General Signal; O-Z/Gedney Unit.
   c. Monogram Co.; AFC.
   d. Square D Co.; Anderson.
   e. 3M Company; Electrical Products Division.

2.2 BUILDING WIRES AND CABLES
   A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Wire and Insulation Applications" Article.
   B. Thermoplastic Insulation Material: Comply with NEMA WC 5.
   C. Conductor Material: Copper.
   D. Stranding: Solid conductor for No. 10 AWG and smaller; stranded conductor for larger than No. 10 AWG.

2.3 CONNECTORS AND SPLICES
   A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.
   B. All feeders 100 Amps and larger shall be terminated with two hole compression indentor lugs, utilizing Belleville washers.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRE AND INSULATION APPLICATIONS
   A. Service Entrance: Type RHW or THWN, in raceway.
   B. Feeders: Type THHN/THWN, in raceway.
   C. Branch Circuits: Type THHN/THWN, in raceway.
   D. Fire Alarm Circuits: Type THHN/THWN, in raceway.
   E. Class 1 Control Circuits: Type THHN/THWN, in raceway.

3.3 INSTALLATION
   A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."
B. Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Seal around cables penetrating fire-rated elements according to Division 7 Section "Firestopping."

F. Identify wires and cables according to Division 26 Section "Electrical Identification."

3.4 CONNECTIONS

A. Conductor Splices: Keep to minimum.

B. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

C. Use splice and tap connectors compatible with conductor material.

D. Use oxide inhibitor in each splice and tap connector for aluminum conductors.

E. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

F. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.

G. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

B. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION
SECTION 26 05 26

GROUNDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 Sections apply to this Section:
   1. "Basic Electrical Requirements."
   2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Section "Wires and Cables."

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for ground rods, connectors and connection materials, and grounding fittings.

C. Field-testing organization certificate, signed by the Contractor, certifying that the organization performing field tests complies with the requirements specified in Quality Assurance below.

D. Report of field tests and observations certified by the testing organization.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

   1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Field-Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.
C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).

D. UL Standard: Comply with UL 467, "Grounding and Bonding Equipment."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Anixter Bros., Inc.
2. Bashlin Industries, Inc.
5. Dossert Corp.
6. Engineered Products Co.
7. Erico Products, Inc.
8. Galvan Industries, Inc.
9. GB Electrical, Inc.
10. General Machine Products Co., Inc.
11. Hastings Fiber Glass Products, Inc.
12. Ideal Industries, Inc.
15. O-Z/Gedney Co.
16. Raco, Inc.
17. Thomas & Betts Corp.
19. Utilco Co.

2.2 GROUNDING AND BONDING PRODUCTS

A. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. Conductor Materials: Copper.

2.3 WIRE AND CABLE CONDUCTORS

A. General: Comply with Section "Wires and Cables." Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.

B. Equipment Grounding Conductor: Green insulated.

B. Isolated Grounding Conductor: Green with yellow tracer insulated.

C. Grounding Electrode Conductor: Stranded cable.

D. Bare Copper Conductors: Conform to the following:

2.4 MISCELLANEOUS CONDUCTORS

A. Ground Bus: Bare annealed copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided No. 30 gage bare copper wire, terminated with copper ferrules.

C. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.5 CONNECTOR PRODUCTS

A. General: Listed and labeled as grounding connectors for the materials used.

B. Pressure Connectors: High-conductivity-plated units.

C. Bolted Clamps: Heavy-duty units listed for the application.

D. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

2.6 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core.
   1. Size: 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATION

A. Equipment Grounding Conductor Application: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.
   1. Install separate insulated equipment grounding conductors with circuit conductors for the following in addition to those locations where required by Code:
      a. Feeders
      b. Receptacle and Special Outlet Circuits.
      c. Single-phase motor or appliance circuits.
      d. Three-phase motor or appliance branch circuits.

B. Signal and Communications: For telephone, alarm, and communication systems, provide a #4 AWG minimum green insulated copper conductor in raceway from the grounding electrode system to each terminal cabinet or central equipment location.
C. Separately derived systems required by NEC to be grounded shall be grounded in accordance with NEC paragraph 250-26.

D. Metal Poles Supporting Outdoor Lighting Fixtures: Ground pole to a grounding electrode in addition to separate equipment grounding conductor run with supply branch circuit.

E. Connections to Lightning Protection System: Bond grounding conductors or grounding conductor conduits to lightning protection down conductors or grounding conductors in compliance with NFPA 78 “Lightning Protection Code.”

F. Common Ground Bonding With Lightning Protection System: Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode. Use bonding conductor sized same as system ground conductor and installed in conduit.

3.2 INSTALLATION

A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.

B. Ground Rods: Locate a minimum of one-rod length from each other and at least the same distance from any other grounding electrode. Interconnect ground rods with bare conductors buried at least 24 inches below grade. Connect bare-cable ground conductors to ground rods by means of exothermic welds except as otherwise indicated. Make these connections without damaging the copper coating or exposing the steel. Use 3/4-inch by 10-ft. ground rods except as otherwise indicated. Drive rods until tops are 6 inches below finished floor or final grade except as otherwise indicated.

D. Metallic Water Service Pipe: Provide insulated copper ground conductors, sized as indicated, in conduit from the building main service equipment, or the ground bus, to main metallic water service entrances to the building. Connect ground conductors to the main metallic water service pipes by means of ground clamps. Where a dielectric main water fitting is installed, connect the ground conductor to the street side of the fitting. Do not install a grounding jumper around dielectric fittings. Bond the ground conductor conduit to the conductor at each end.

E. Braided-Type Bonding Jumpers: Install to connect ground clamps on water meter piping to bypass water meters electrically. Use elsewhere for flexible bonding and grounding connections.

F. Route grounding conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.

G. UFER Ground: Fabricate with 20 feet of conductor laid lengthwise in excavation for foundation or footings. Install so conductor is within 2 inches of the bottom of the concrete. Where base of foundation is less than 20 feet in length, coil excess conductor at base of foundation. Bond conductor to reinforcing steel at four locations, minimum. Extend conductor below grade and connect to building grounding grid or grounding electrode.
3.3 CONNECTIONS

A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
2. Make connections with clean bare metal at points of contact.
3. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.

B. Exothermic Welded Connections: Use for connections to structural steel and for underground connections except those at test wells. Install at connections to ground rods and plate electrodes. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

D. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

F. Compression-Type Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

G. Moisture Protection: Where insulated ground conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

3.6 FIELD QUALITY CONTROL

A. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified, at service disconnect enclosure ground terminal, and at ground test wells. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method in accordance with Section 9.03 of IEEE 81, "Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System."
B. Ground/resistance maximum values shall be as follows:
   1. 3 Ohms

C. Deficiencies: Where ground resistances exceed specified values, and if directed, modify the
grounding system to reduce resistance values. Where measures are directed that exceed
those indicated the provisions of the Contract, covering changes will apply.

D. Report: Prepare test reports, certified by the testing organization, of the ground resistance at
each test location. Include observations of weather and other phenomena that may affect test
results. Describe measures taken to improve test results.

3.7 CLEANING AND ADJUSTING

A. Restore surface features at areas disturbed by excavation and reestablish original grades
   except as otherwise indicated. Where sod has been removed, replace it as soon as possible
   after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable
   laying, and other Work to their original condition. Include necessary topsoiling, fertilizing,
   liming, seeding, sodding, sprigging, or mulching. Perform such Work in accordance with
   Section "Landscape Work." Maintain disturbed surfaces. Restore vegetation in accordance
   with Section "Landscape Work." Restore disturbed paving as indicated.

END OF SECTION
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 Sections apply to this section:
   1. "Basic Electrical Requirements."
   2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified.
   1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

C. Shop drawings indicating details of fabricated products and materials.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Component and installation shall comply with NFPA 70 "National Electrical Code."

B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Slotted Metal Angle and U-Channel Systems:
      a. Allied Tube & Conduit
      b. American Electric
      c. B-Line Systems, Inc.
      d. Cinch Clamp Co., Inc.
2. Conduit Sealing Bushings:
   a. Bridgeport Fittings, Inc.
   b. Cooper Industries, Inc.
   d. GS Metals Corp.
   f. Madison Equipment Co.
   g. L.E. Mason Co.
   h. O-Z/Gedney
   i. Producto Electric Corp.
   j. Raco, Inc.
   k. Red Seal Electric Corp.
   l. Spring City Electrical Mfg. Co.
   m. Thomas & Betts Corp.

2.2 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:
   1. Expansion Anchors: Carbon steel wedge or sleeve type.
   2. Toggle Bolts: All steel springhead type.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.4 FABRICATED SUPPORTING DEVICES
A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:
   1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
      a. 3-inch and smaller: 20-gage.
      b. 4-inch to 6-inch: 16-gage.
      c. over 6-inch: 14-gage.
   2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electric components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
   1. Conform to manufacturer's recommendations for selection and installation of supports.
   2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
   3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
   4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
   5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
   6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
   7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
   8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
D. Vertical Conductor Supports: Install simultaneously with installation of conductors. Provide supports at lengths no greater than 30 feet.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire-rated wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Fire Resistant Joint Sealers" requirement of Division 7 Section "Joint Sealers."

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

J. TESTS: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:

1. Expansion anchors.
2. Toggle bolts.

K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.
3.2 **TABLE I: SPACING FOR RACEWAY SUPPORTS**

<table>
<thead>
<tr>
<th>Raceway Size (Inches)</th>
<th>No. of Conductors in Run</th>
<th>Maximum Spacing Supports (Feet)</th>
<th>Location</th>
<th>HGR &amp; IMC*</th>
<th>EMT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HORIZONTAL RUNS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>1 or 2</td>
<td>Flat ceiling or wall.</td>
<td>5</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>1 or 2</td>
<td>Where it is difficult to provide supports except at intervals fixed by the building construction,</td>
<td>7</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>3 or more</td>
<td>Flat ceiling or wall.</td>
<td>6</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>1/2-1</td>
<td>1 or 2</td>
<td>Flat ceiling or wall.</td>
<td>10</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>1 &amp; larger</td>
<td>1 or 2</td>
<td>Flat ceiling or wall.</td>
<td>10</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Any</td>
<td>3 or more</td>
<td>Any location.</td>
<td>10</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td><strong>VERTICAL RUNS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2, 3/4</td>
<td>3 or more</td>
<td>Exposed.</td>
<td>7</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>1, 1-1/4</td>
<td>3 or more</td>
<td>Exposed.</td>
<td>8</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>1-1/2 and larger</td>
<td>Exposed.</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 2</td>
<td>Shaftway.</td>
<td>14</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1/2</td>
<td>Shaftway.</td>
<td>16</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &amp; larger</td>
<td>Shaftway.</td>
<td>20</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any</td>
<td>Concealed</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

**Abbreviations:**
- EMT: Electrical metallic tubing.
- IMC: Intermediate metallic conduit.
- GRC: Rigid metallic conduit.

**END OF SECTION**
SECTION 26 05 33
CABINETS, BOXES, AND FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 Sections apply to this section:

1. "BASIC ELECTRICAL REQUIREMENTS."

1.2 SUMMARY

A. This section includes cabinets, boxes, and fittings for electrical installations and certain types of electrical fittings not covered in other sections. Types of products specified in this Section include:

1. Outlet and device boxes.
2. Pull and junction boxes.
3. Floor boxes and service fittings.
5. Hinged door enclosures.
6. Boxes and fittings for hazardous locations.

1.3 DEFINITIONS

A. Cabinets: An enclosure designed either for surface or for flush mounting and having a frame, or trim in which a door or doors may be mounted.

B. Device Box: An outlet box designed to house a receptacle device or a wiring box designed to house a switch.

C. Enclosure: A box, case, cabinet, or housing for electrical wiring or components.

D. Hinged Door Enclosure: An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box.

E. Outlet Box: A wiring enclosure where current is taken from a wiring system to supply utilization equipment.

F. Wiring Box: an enclosure designed to provide access to wiring systems or for the mounting of indicating devices or of switches for controlling electrical circuits.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and other Specification Sections:

1. Product data for cabinets and enclosures with classification higher than NEMA 1.
2. Shop drawings for floor boxes and boxes, enclosures and cabinets that are to be shop fabricated, (nonstock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

1.5 QUALITY ASSURANCE

A. UL Listing and Labeling: Items provided under this section shall be listed and labeled by UL.

B. Nationally Recognized Testing Laboratory Listing and Labeling (NRTL): Items provided under this section shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

C. National Electrical Code Compliance: Components and installation shall comply with NFPA 70 "National Electrical Code."

D. NEMA Compliance: Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Floor Boxes:
   c. Cooper Industries, Inc.
   d. Raco, Inc.
   e. Thomas & Betts Corp.

2. Cabinets:
   a. Electric Panelboard, Inc.
   b. Erickson Electrical Equipment Co.
   e. Spring City Electrical Mfg. Co.
   f. Square D Co.

3. Boxes and Fittings for Hazardous Locations:
   a. Adalet-PLM.
   b. Cooper Industries, Inc.
   d. OZ/Gedney.
   e. Robroy Industries, Inc.
   f. Spring City Electrical Mfg. Co.
2.2 CABINETS, BOXES, AND FITTINGS, GENERAL

A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations.

2.3 MATERIALS AND FINISHES

A. Sheet Steel: Flat-rolled, code-gage, galvanized steel.

B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.

D. Cast Metal for Boxes, Enclosures, and Covers: Copper-free aluminum except as otherwise specified.

E. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.

F. Painted Interior Finish: Where indicated, white baked enamel.

G. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 14B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connectors.

2.4 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES

A. General: Conform to UL 514A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size, and depth to suit each location and application.

B. Steel Boxes: Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports." Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.

C. Steel Floor Boxes: Sheet steel, concrete tight, fully adjustable, with stamped knockouts, adjusting rings, and brass floor plates. Where indicated, provide multi-section boxes with concealed individual section covers under a common flush floor plate. Provide for a duplex receptacle in one of the concealed section covers and a one inch diameter bushed opening in the other.

2.5 PULL AND JUNCTION BOXES

A. General: Comply with UL 50, "Electrical Cabinets and Boxes", for boxes over 100 cubic inches volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.
B. Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.

C. Hot-Dipped Galvanized Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.

D. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 302 of ASTM A 167, "Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." Where necessary to provide a rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.

E. Boxes Approved for Classified Locations: Cast metal or cast nonmetallic boxes conforming to UL 886, "Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations," listed and labeled for use in the specific location classification, and with the specific hazardous material encountered. Conduit entrances shall be integral threaded type.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.

B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.

C. Support and fasten items securely in accordance with Division 16 Section "Supporting Devices."

D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.

E. Remove sharp edges where they may come in contact with wiring or personnel.

3.2 APPLICATIONS

A. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements.

1. Interior Dry Locations: Sheet steel, NEMA type 1.
2. Locations Exposed to Weather or Dampness: Cast metal, NEMA type 3R.
3. Wet Locations: NEMA type 4 enclosures.
5. Hazardous (Classified) Locations: NEMA type listed and labeled for the location and class of hazard indicated.

B. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.

C. Floor Boxes: In slabs on grade and wet locations use NEMA type 4 boxes. At other locations in slabs, use concrete-tight NEMA 1 boxes.
3.3 INSTALLATION OF OUTLET BOXES

A. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

B. Gasketed Boxes: At the following locations use cast metal, threaded hub type boxes with gasketed weatherproof covers:
   1. Exterior locations.
   2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
   3. Where exposed to moisture laden atmosphere.
   4. At food preparation equipment within four ft. of steam connections.
   5. Where indicated.

C. Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.

D. Mounting: Mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles either vertically or horizontally but consistently either way. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side.

E. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4-inches square by 1-1/2-inches deep, minimum.

F. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.

G. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.

H. Concrete Boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6-inch depth.

I. Floor Boxes: Install in concrete floor slabs so they are completely enveloped in concrete except for the top. Where normal slab thickness will not envelop box as specified above, provide increased thickness of the slab. Provide each compartment of each floor box with grounding terminal consisting of a washer-in-head machine screw, not smaller than no. 10-32, screwed into a tapped hole in the box. Adjust covers of floor boxes flush with finished floor.

J. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in the rings to align with the mounting holes on the existing boxes where existing holes are not aligned.

3.4 INSTALLATION OF PULL AND JUNCTION BOXES

A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8-inches square by 4-inches deep. Do not exceed 6 entering and 6 leaving raceways in a single box.
Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed the following:

<table>
<thead>
<tr>
<th>Size of Largest Conductors in Box</th>
<th>Maximum number of Conductors in Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4/0 AWG</td>
<td>30</td>
</tr>
<tr>
<td>250 MCM</td>
<td>20</td>
</tr>
<tr>
<td>500 MCM</td>
<td>15</td>
</tr>
<tr>
<td>Over 500 MCM</td>
<td>10</td>
</tr>
</tbody>
</table>

1. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30-inches inside boxes.

2. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.

3. Size: Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Article 370 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.5 GROUNDING

A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box or enclosure.

3.6 CLEANING AND FINISH REPAIR

A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions and weld marks.

B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the tray manufacturer.

C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
   B. Requirements of the following Division 26 Sections apply to this Section:
      1. Basic Electrical Requirements.
      2. "Basic Electrical Materials and Methods."

1.2 SUMMARY
   A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
      1. Electrical metallic tubing (EMT).
      2. Flexible metal conduit.
      3. Intermediate metal conduit.
      4. Liquidtight flexible conduit.
      5. Rigid metal conduit.
   B. Related Sections: The following Division 26 Sections contain requirements that relate to this Section:
      1. Wires and Cables" for other wiring methods.
      3. "Electrical Boxes and Fittings" for boxes used with conduit and tubing systems.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
   B. Product Data for the following products:
      1. Raceway and fittings.

1.4 QUALITY ASSURANCE
   A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
   B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.
   C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL, ETL, or CSA.
1.5 SEQUENCING AND SCHEDULING
   A. Coordinate with other Work, including metal and concrete deck installation, as necessary to
      interface installation of electrical raceways and components with other Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   B. Conduit Bodies:
      1. Adalet-PLM
      2. American Electric
      3. Appleton Electric Co.
      4. Carlon
      5. Crouse-Hinds Division, Cooper Industries, Inc.
      6. Delta Industrial Products
      8. Kraloy Products Co.
      9. O-Z/Gedney
      10. Spring City Electrical Mfg. Co.

2.2 METAL CONDUIT AND TUBING
   A. Rigid Aluminum Conduit: ANSI C80.5.
   B. Rigid Steel Conduit: ANSI C80.1.
   C. Intermediate Steel Conduit: UL 1242.
   D. PVC Externally Coated Rigid Steel Conduit and Fittings: ANSI C80.1 and NEMA RN 1.
   E. Electrical Metallic Tubing and Fittings: ANSI C80.3.
   F. PVC Externally-Coated Electrical Metallic Tubing and Fittings: ANSI C80.3 and NEMA RN 1.
   G. Flexible Metal Conduit: UL 1, zinc-coated steel.
   H. Liquidtight Flexible Metal Conduit and Fittings: UL 360. Fittings shall be specifically approved
      for use with this raceway.
   I. PVC Conduit

2.3 CONDUIT BODIES
   A. General: Types, shapes, and sizes as required to suit individual applications and NEC
      requirements. Provide matching gasketed covers secured with corrosion-resistant screws.
   B. Metallic Conduit and Tubing: Use only malleable iron metallic conduit bodies. Use bodies with
      threaded hubs for threaded raceways.
   C. Conduit Bodies and Couplings: Use only steel bodies with gland ring compression-threaded
      type EMT connectors with insulated throats. Diecast bodies are not acceptable.

PART 3 - EXECUTION

3.1 WIRING METHOD
   A. Outdoors: Use the following wiring methods:
1. Exposed: rigid metal conduit.
2. Concealed: intermediate metal conduit.
5. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment: liquidtight flexible metal conduit.
6. Indoors or Outdoors: Connection to vibrating equipment and hydraulic, pneumatic, or electric solenoid or motor-driven equipment in moist or humid location or corrosive atmosphere, or where subject to water spray or dripping oil, grease, or water: liquidtight flexible metal conduit.

B. Indoors: Use the following wiring methods:

1. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic or electric solenoid or motor-operated equipment: flexible metal conduit.
2. Exposed: electrical metallic tubing.
4. For service entrance and generator feeders, use GRC conduit with watertight seals at any penetration through exterior walls.
5. All raceways exposed to physical damage shall be installed in rigid metal conduit or intermediate metal conduit.

C. Electrical Metallic Tubing (EMT) is excluded from use in the following locations or under the following conditions:

1. Outside structure or on roof.
2. At or below grade.
3. In or beneath slabs on grade.
4. In hazardous locations.
5. Where exposed to physical damage.
6. Where subject to excessive moisture or deterioration.
7. High voltage raceways.
8. For service entrance and generator feeders.

3.2 INSTALLATION

A. General: Install electrical raceways in accordance with manufacturer's written installation instructions, applicable requirements of NEC, and as follows:

B. Conceal Conduit and EMT, unless indicated otherwise, within finished walls, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install raceways level and square and at proper elevations.

C. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.

D. Complete installation of electrical raceways before starting installation of conductors within raceways.

E. Provide supports for raceways as specified elsewhere in Division 26.

F. Prevent foreign matter from entering raceways by using temporary closure protection.

G. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
H. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

I. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

J. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated. This does not apply to conduits in crawl spaces.

K. Raceways embedded in slabs: Install in middle third of the slab thickness where practical and leave at least 1 inch concrete cover. Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in the concrete. Run conduit larger than 1-inch trade size, parallel with or at right angles to the main reinforcement; where at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Where nonmetallic conduit or tubing is used, raceways must be converted to Schedule 80 or rigid steel conduit or tubing IMC before rising above floor.

L. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

M. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways.

N. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.

O. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.

P. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

Q. Install pull wires in empty raceways. Use no. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

R. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-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 and elsewhere as indicated:

1. Where conduits enter or leave hazardous locations.
2. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
3. Where required by the NEC.

S. Size conduits to meet NEC, except no conduit shall be smaller than 3/4 inch. No underground conduit shall be smaller than 1 inch.
3.3 ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

END OF SECTION
SECTION 26 05 35
WIRING DEVICES

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes receptacles, connectors, switches, and finish plates.

1.3 DEFINITIONS
A. GFCI: Ground-fault circuit interrupter.
B. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS
A. Product Data: For each product specified.
B. Shop Drawings: Legends for receptacles and switch plates.
C. Maintenance Data: For materials and products to include in maintenance manuals specified in Division 1.

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.
B. Comply with NEMA WD 1.
C. Comply with NFPA 70.

1.6 COORDINATION
A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Wiring Devices:
      a. Bryant Electric, Inc.
      b. Eagle Electric Manufacturing Co., Inc.
      c. GE Company; GE Wiring Devices.
e. Killark Electric Manufacturing Co.
f. Leviton Manufacturing Co., Inc.
g. Pass & Seymour/Legrand; Wiring Devices Div.
h. Pyle-National, Inc.; an Amphenol Co.

2. Multioutlet Assemblies:
   a. Airey-Thompson Co.
   b. Wiremold.

3. Poke-through, Floor Service Outlets and Telephone/Power Poles:
   c. Pass & Seymour/Legrand; Wiring Devices Div.
   d. Square D Co.
   e. Wiremold.

2.2 RECEPTACLES

A. Straight-Blade and Locking Receptacles: Heavy-Duty grade.

B. Isolated-Ground (IG) Receptacles: Equipment grounding contacts connected only to the green grounding screw terminal of the device with inherent electrical isolation from mounting strap.
   1. Devices: Listed and labeled as isolated-ground receptacles.
   2. Isolation Method: Integral to receptacle construction and not dependent on removable parts.
   3. IG devices shall have small orange triangle on face with primary color of device to match other, non-IG devices.

C. All Devices located in children’s areas shall have child protective covers.

2.3 SWITCHES

A. Snap Switches: Heavy-duty, quiet type. ‘Decora-style’ switches for public areas other than support rooms (electrical, mechanical, janitor, etc.).

B. Dimmer Switches: Modular, full-wave, solid-state units, ‘Decora-style’, slider type with integral, quiet on/off switches and audible and electromagnetic noise filters.

2.4 WALL PLATES

A. Single and combination types match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: 0.04-inch thick, Type 302, satin-finished stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies plumb and secure.

B. Install wall plates when painting is complete.

C. Install wall dimmers to achieve indicated rating after derating for ganging as instructed by manufacturer.
D. Do not share neutral conductor on load side of dimmers.

E. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

F. Protect devices and assemblies during painting.

G. Adjust locations at which floor service outlets and telephone/power service poles are installed to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION
A. Comply with Division 26 Section "Electrical Identification."

3.3 CONNECTIONS
A. Connect wiring device grounding terminal to outlet box with bonding jumper.

B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.

C. Isolated-Ground Receptacles: Connect to isolated-ground conductor routed to designated isolated equipment ground terminal of electrical system.

D. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL
A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.5 CLEANING
A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION
PART 1   GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this section.

1.2 WORK INCLUDED
A. Vibration Isolation
B. Sealing Around Penetrations Through Walls and Slabs
C. Sealant
D. Installation of flexible conduit between non-isolated construction and isolated construction, including mechanical equipment, fans, pumps, and bridging between isolated room-within-a-room and non-isolated adjacent construction.

1.3 RELATED WORK SPECIFIED ELSEWHERE
A. Consult all other Sections to determine the extent of work specified elsewhere but related to this Section. This work shall be properly coordinated to produce an installation satisfactory to the Owner.
B. Installation of Transformers
C. Performance Lighting System
D. Electric Service Distribution
E. Concrete Housekeeping Pads
F. General Lighting Systems

1.4 DEFINITIONS
A. The term "or as approved" means the contractor may propose an alternate product, but the consultant shall be sole judge of acceptability of alternate products. The term "Contractor" as used in this Section refers to that contractor directly responsible for the supply and installation of the Electrical Systems, including noise and vibration control.

1.5 CONTRACTOR'S RESPONSIBILITY
A. The Electrical Contractor shall be directly responsible for the supply and installation of noise and vibration control equipment and work for the Electrical Systems.
B. The Contractor shall be responsible for providing a complete and suitable installation of isolation equipment to meet the intent of this specification. Any additional equipment needed to meet the intent of this specification, even if not specifically mentioned herein or on the drawings, shall be supplied by the Contractor without claim for additional payment.
C. The Contractor shall provide seismic restraints for all vibration isolation systems where required by code, and as specified elsewhere in these Specifications. The Contractor shall submit drawings and specifications, certifying that the installation will meet all local seismic restraint requirements. The Contractor shall also certify that none of the required seismic restraints will reduce the isolation efficiency of any vibration isolation systems.

D. Performance or waiving of inspection, testing or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly with the Contract Documents. The Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architects to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.

1.6 MANUFACTURER'S RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:

1. Determine vibration isolation for all equipment and systems in accordance with all codes and authorities having jurisdiction on this project.
2. Provide equipment isolation systems as scheduled or specified.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. The vibration isolation systems shall be guaranteed to have deflection indicated on the schedule on the drawings. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instructions.
6. The vibration isolator vendor shall ensure that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators. Where additional support structure is required, this shall be provided by vibration isolator vendor.

1.7 APPROVED MANUFACTURERS

A. All noise and vibration control apparatus shall be furnished by a single manufacturer who has supplied isolation equipment for at least five years. The vendor shall design and provide all hangers, isolators, bases, pads, sleeves and other devices specified, required, or detailed for the vibration isolation of all electrical equipment and conduit. The vendor for vibration control equipment shall be one of the following, or as approved:

1. Mason Industries Inc.
2. Amber-Booth
3. Kinetics Noise Control

1.8 BID PROPOSALS

A. The Contractor shall submit at the time of bidding the names and qualifications of the noise and vibration control supplier(s). If a supplier is not one of the pre-approved vendors, then the submittal shall be accompanied by a complete catalog of that supplier's products and samples of each proposed vibration isolator with reference to the specification part number.

1.9 SHOP DRAWINGS

A. Fully coordinated shop drawings for all vibration and noise control equipment and systems shall be submitted by the Contractor for review by the Owner's Consultants. These submittals shall state the performance of the noise and vibration control products to be provided, such as, but not limited to, the following: vibration isolator model or type, size and
static deflection; isolator location shown on an outline of the isolated equipment; seismic restraints; installation details; locations of isolated conduit hangers on conduit layout plans; materials and details for penetrations, including penetrations by groups of conduits, and locations of acoustically sealed pull boxes.

1.10 NOISE CRITICAL SPACES

A. The Auditorium and platform, A/V Production Rooms as well as all mechanical and electrical equipment rooms have been designated as “noise-critical spaces”. Special acoustical provisions shall apply for penetrations of conduit through walls and slabs surrounding these areas.

1.11 DESCRIPTION OF SYSTEMS

A. VIBRATION ISOLATION

1. Vibration isolators shall be installed to attenuate the vibration transfer from equipment such as transformers, lighting dimmers, lighting ballasts, controls and relays to reduce vibration.

2. Flexible connections shall also be supplied for conduit and wiring serving electrical equipment on vibration isolators to ensure complete isolation of such equipment.

B. TRANSFORMERS

1. Transformers shall be located only where shown on the drawings. The noise sensitivity of this facility requires that all noise-critical spaces be well isolated from transformer noise and vibration.

C. SEALING OF PENETRATIONS

1. Electrical equipment generates noise that has a tonal quality that can be very disturbing in performance spaces. Walls and doors within the cave can effectively isolate air-borne noises from noise critical spaces, but the effectiveness of sound isolating structures can be severely compromised by penetrations for electrical conduit. Proper sealing around and inside conduits passing through penetrations as described herein will maintain the integrity of the sound isolating structure.

2. Special “acoustically sealed pull boxes” shall be used where a group of conduits penetrate a noise critical wall. These heavy-duty, airtight pull boxes are used to reduce the leakage of sound through the conduit walls and thus through the structure.

PART 2 PRODUCTS

2.1 MATERIALS

A. FOAM ROD

1. Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

B. NON-HARDENING SEALANT

1. Sealant for electrical penetrations shall be non-hardening polysulphide type.

2. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise sensitive walls that are also fire rated.

2.2 EQUIPMENT

Trinity Valley Community College
Health Science Center
RSA Project No. 1707.00

ELECTRICAL NOISE AND VIBRATION CONTROL
50% CD’S / GMP Pricing
RSA Project No. 1707.00
26 05 48 - 3
December 29, 2017
A. GENERAL

1. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.

B. VIBRATION ISOLATORS

1. GENERAL

a. The static deflection of isolators shall be as given in the equipment schedule and specified below.

b. Vibration isolator sizes and layout shall be determined by the vibration isolator supplier to meet performance criteria below. Static deflections specified shall be met with equipment fully operational.

2. ISOLATOR TYPE WP

a. Type WP (Waffle Pads) shall be minimum 5/16” thick neoprene pads ribbed or waffled on both sides. The pads shall be selected for 15% strain. Neoprene shall be bridge-bearing quality with a maximum durometer of 50. Where required to meet this strain criterion, steel load-spreading plates shall be incorporated between the equipment and the neoprene pad. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

3. ISOLATOR TYPE MWP

a. Type MWP (Metal and Waffle Sandwich Pads) shall consist of two 5/16” thick ribbed or waffle neoprene pads sandwiching a 16-gauge stainless steel plate. The pad shall be designed for 15% strain. Neoprene shall be bridge-bearing quality with a maximum durometer of 50. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

4. NEOPRENE MOUNTING SLEEVES

a. Neoprene mounting sleeves for hold-down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.

C. ACOUSTICALLY SEALED PULL BOXES

1. Sides and cover shall be formed of minimum 14-gauge cold rolled steel. Inside surfaces of sides and cover shall be lined with 1” thick, neoprene-coated duct liner board of 3 pcf density. Entire perimeter of closure shall be sealed with 1” x 1/4” closed-cell sponge neoprene sound seal. Sides of the box shall be sealed airtight to the wall with non-hardening sealant on foam backer rod. Conduit penetrations through wall shall be packed and caulked as described herein.

PART 3 EXECUTION

3.1 GENERAL
A. Ballasts, relays, dimmers, equipment controls and all transformers shall be located as shown on the drawings. If not shown, location is subject to review by architect and acoustical consultant prior to installation. Under no circumstances shall such devices be located within noise critical spaces or on walls, slabs or ceilings that are common to such spaces.

3.2 TRANSFORMERS

A. All transformers shall be installed on Type SPNM or SPNH spring isolators. All wiring connections to a transformer on Type SPNM or Type SPNH isolators shall be made with a slack U-shape section of flexible conduit. Wiring connections to a transformer supported on Type DDNM or Type DDNH isolators shall be made with a slack U-shaped flexible conduit or as approved.

B. Transformers shall not be hung from or supported on other equipment, pipes or ductwork installed on vibration isolators, but shall be supported on or suspended from building structure.

3.3 DIMMER RACKS

A. Dimmer racks and other lighting equipment containing transformers, fans, choke coils or relays shall be installed on Type MWP isolation pads and shall be located a minimum of 3" from adjacent walls. Conduit within the dimmer rooms shall be suspended on Type DDNH neoprene hangers.

3.4 MOTORS AND ELECTRICAL EQUIPMENT

A. All wiring connections to motors and electrical equipment supported on Type SPNM or Type SPNH isolators shall be made with a slack U-shaped section of flexible conduit. Wiring connections to motors and electrical equipment supported on Type DDNM and or Type DDNH isolators shall be made with a slack U-shaped flexible conduit. Flexible conduit and cable shall be capable of and recommended for such curvature.

3.5 MOTOR CONTROL CENTERS

A. Motor control centers shall be mounted on Type MWP isolators.

3.6 SOUND SYSTEM RACKS

A. All sound and communication racks shall be mounted on Type MWP isolators.

3.7 ACOUSTICALLY SEALED PULL BOXES

A. Acoustically sealed pull boxes as described herein shall be installed at one side of each penetration at noise critical walls and slabs where the pull box exceeds 8" in at least one dimension.

3.8 PENETRATIONS OF WALLS AND SLABS

A. All conduit and cable penetrations of noise critical spaces shall be sleeved, packed and caulked airtight.

B. Where a conduit or cable passes through such a wall or slab, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be larger than the external diameter of the conduit passing through it by 2" for conduit 2" and over and by 1" for conduit under 2". After all of the conduit is installed, the Electrical Contractor shall check the clearance and correct it, if necessary, to within 1/2". The void shall be packed full depth with
glass fiber; install foam backer rod on both sides, recessed into the sleeve by 1/2". Cover the backer rod 1/2" deep with non-hardening, non-aging sealant. Alternatively, the void between sleeve and conduit shall be filled full-depth with GE silicone sealant Type RTV6428 or approved material with equal density and flexibility. For penetrations in fire-rated assemblies, use approved non-hardening, non-shrinking fire stop putty in lieu of the sealant and foam rod.

C. Where conduit crosses a building expansion joint between new and existing buildings, an 18” length of flexible conduit shall be used to bridge between the two constructions. Rigid conduit shall not be acceptable.

3.9 FIELD QUALITY

A. Contractor shall work in accord with best trade practices, shall fabricate and install all items in accordance with manufacturer's recommendations and Architect's directions, and shall consult and coordinate with trades doing adjoining work in order to provide an installation of first class quality.

3.10 TESTING AND ADJUSTMENT

A. Contractor shall test and adjust noise and vibration control products and installations to achieve specified performance.

3.11 CONTRACTOR’S REPORT

A. The vibration isolation manufacturer shall inspect and approve the installation of the vibration isolators, and shall submit a report to the Architect and Acoustics Consultant which verifies that all of the isolators for electrical equipment has been properly installed and that the installation is in full conformance with the specification. The report shall contain the type and measured static deflection of all spring isolators provided.

3.12 SITE ACCESS

A. During installation of equipment, Contractor shall arrange for access as necessary for inspection of isolation and noise control equipment by Architect and Acoustics Consultant.

3.13 CONSULTANT’S INSPECTION

A. Upon completing installation and adjustment for suitable operation of all work specified under this section, the Contractor shall notify in writing the Architect, who will schedule an inspection by the Acoustics Consultant. The letter shall certify that all work specified under this section is complete, operational and adjusted in every respect, and that all work is ready for the completion checkout. Defective equipment and installation shall be repaired at the cost of the Contractor, and another inspection shall be scheduled.

B. In the event that a second (or subsequent) inspection is required, the Contractor shall reimburse the Owner for travel, food and accommodation expenses incurred by the Consultant and passed on to the Owner.

C. For each inspection, workmen shall be furnished to perform such functions as are necessary for inspection of the equipment.

END OF SECTION
SECTION 26 05 53
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 Sections apply to this section:

1. "Basic Electrical Requirements."
2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:

1. Buried electrical line warnings.
2. Identification labeling for raceways, cables, and conductors.
3. Equipment labels and signs.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section "Wires and Cables" for requirements for color coding of conductors for phase identification.

C. Refer to other sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. American Labelmark Co.
2. Calpico, Inc.
3. Cole-Flex Corp.
4. Emed Co., Inc.
5. George-Ingraham Corp.
6. Ideal Industries, Inc.
7. Kraftbilt
8. LEM Products, Inc.
9. Markal Corp.
11. Panduit Corp.
12. Radar Engineers Div., EPIC Corp.
13. Seton Name Plate Co.
15. W.H. Brady Co.

2.2 ELECTRICAL IDENTIFICATION PRODUCTS

A. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

B. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in white letters on black face and punched for mechanical fasteners.

C. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50 deg F to 350 deg F. Provide ties in specified colors when used for color coding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.
C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

D. Identify Junction, Pull, and Connection Boxes: Label cover with black indelible marker with panel and circuit number.

E. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

<table>
<thead>
<tr>
<th>208/120 Volts</th>
<th>Phase</th>
<th>480/277 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>Yellow</td>
</tr>
<tr>
<td>Red</td>
<td>B</td>
<td>Brown</td>
</tr>
<tr>
<td>Blue</td>
<td>C</td>
<td>Orange</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>Green</td>
<td>Ground</td>
<td>Green</td>
</tr>
</tbody>
</table>

F. Use conductors with color factory-applied the entire length of the conductors except as follows:

1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG.
   a. Apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
   b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.

G. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrat signs with metal backing for outdoor items.

2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

H. Install equipment/system circuit/device identification as follows:

1. Apply equipment identification labels of engraved plastic-laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/signal/alarm systems, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 1/2-inch-high lettering on 1-1/2-inch-high label (2-inch-high where two lines are required), white lettering in black field. Text shall match terminology and
numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment.

a. Panelboards, electrical cabinets, and enclosures.
b. Access doors and panels for concealed electrical items.
c. Electrical switchgear and switchboards.
d. Electrical substations.
e. Motor disconnects.
f. Motor starters.
g. Pushbutton stations.
h. Power transfer equipment.
i. Contactors.
j. Remote-controlled switches.
k. Control devices.
l. Transformers.
m. Telephone switching equipment.
n. Fire alarm master station or control panel.
o. Security monitoring master station or control panel.

I. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

J. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

K. Label each electrical junction box with panel and circuit number on cover with permanent black felt marker.

L. Label each wiring device on face plate with panel and circuit number designation.

END OF SECTION
SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device
   coordination studies, and the setting of these devices.

   1. Series-rated devices are permitted for one level of protection only and where indicated
      on Drawings.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software
   programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals:

   1. Coordination-study input data, including completed computer program input data
      sheets.
   2. Coordination-study report.
   3. Equipment evaluation report.
   4. Setting report.

1.4 QUALITY ASSURANCE

A. Coordination study shall be performed by a registered professional engineer in the State in
   which the projects is being constructed.

B. In accordance with latest version of ANSI/IEEE Standard 242, "Recommended Practice for
   Protection and Coordination of Industrial and Commercial Power Systems."

C. Studies shall use computer programs that are distributed nationally and are in wide use. Software
   algorithms shall comply with requirements of standards and guides specified in this
   Section. Manual calculations are not acceptable.

D. Coordination-Study Specialist Qualifications: An organization experienced in the application
   of computer software used for studies, having performed successful studies of similar
   magnitude on electrical distribution systems using similar devices.

F. Comply with IEEE 399 for general study procedures.

G. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

PART 2 PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide computer software programs developed by one of the following:

1. EDSA Micro Corporation.
2. Electrical Systems Analysis, Inc.
3. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.

1. Optional Features:
   a. Arcing Flash Analysis.
   b. Fault Current Analysis.
   c. Arc Flash Labeling.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.2 FAULT-CURRENT STUDY

A. Coordination study shall be performed by a State of Texas registered professional engineer in accordance with latest version of ANSI/IEEE Standard 242, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems." Source Impedance: Utility company's fault-current contribution or as an infinite bus on primary side of utility transformer, with transformer impedance information furnished by the utility company.

B. Study shall be performed, coordinated with and provided with electrical gear submittals.
C. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

D. Calculate momentary and interrupting duties on the basis of maximum available fault current.

E. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:
   2. Low-Voltage Fuses: IEEE C37.46.

F. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

G. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.3 COORDINATION STUDY

A. Furnish a complete overcurrent protective device coordination study for the entire electrical system of this project. Show graphically how overcurrent protective devices coordinate selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics curves, device performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices. All fault current calculations and time current coordination curves shall be performed on nationally recognized computer software. Study shall include both upstream (utility company) and downstream devices to insure proper coordination throughout the system. Provide separate series of specific ground fault coordination curves.

B. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 16 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical distribution system diagram showing the following:
   a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
   b. Circuit-breaker and fuse-current ratings and types.
   c. Relays and associated power and current transformer ratings and ratios.
   d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   e. Generator kilovolt amperes, size, voltage, and source impedance.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Magnetic inrush current overload capabilities of transformers.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Ratings, types, and settings of utility company's overcurrent protective devices.
   e. Special overcurrent protective device settings or types stipulated by utility company.
   f. Time-current-characteristic curves of devices indicated to be coordinated.
   g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

C. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

D. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

E. Comply with IEEE 242 recommendations for fault currents and time intervals.

F. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

G. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

I. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information, each device in a different color:
   a. Device tag.
   b. Voltage and current multiplier for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. Non-damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.
   h. Motor starting and running curves.
   i. Generator decrement curves.

3. Completed data sheets for setting of overcurrent protective devices.

3.4 ARC FLASH STUDY
   A. Incident Energy Study – An incident energy study shall be done in accordance with the IEEE 1584-2004a, "IEEE Guide for Performing Arc Flash Hazard Calculations" as referenced in NFPA 70, "Standard for Electrical Safety in the Workplace", 2004 Revision, in order to quantify the hazard for selection of personal protective equipment (PPE). Tables that assume fault current levels and clearing time for proper PPE selection are not acceptable. Study shall be commissioned and paid for by the Contractor.
   B. Provide arc flash labels on all switchboards, panelboards, etc as required by NFPA 70E.
   C. Labels shall be located so as to be clearly visible to qualified personal before examination, adjustment, servicing, or maintenance of the equipment.

3.5 OVERCURRENT PROTECTIVE DEVICE SETTING
   A. Manufacturer's Field Service: Engage an independent testing agency or a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to set overcurrent protective devices within equipment.
   B. Testing: Perform the following device setting and prepare test reports:
      1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:
         a. Verify that overcurrent protective devices meet parameters used in studies.
         b. Adjust devices to values listed in study results.
         c. Test all devices greater than 100 Amps by injecting primary current to verify that protective device trips at specified settings.
      2. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

END OF SECTION
SECTION 26 09 23
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 1 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
B. Related Sections include the following:
   1. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS
A. Product Data: Include dimensions and data on features, components, and ratings for lighting control devices.
B. Maintenance Data: For lighting control devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.
B. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
C. Comply with NFPA 70.

1.5 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 "Panelboards."
   2. Division 26 Section "Wiring Devices."

PART 2 - PRODUCTS

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

1. Contactors and Relays:
   a. Automatic Switch Co.
   b. GE Lighting Controls.
   c. Square D Co.
   d. Zenith Controls, Inc.
2. Time Switches:
   a. Paragon Electric Co., Inc.
   b. Tork, Inc.
3. Occupancy Sensors:
   b. Novitas, Inc.
   c. Unenco Electronics (A Hubbell Co.).
   d. Watt Stopper, Inc. (The).
   e. Leviton, Inc.

2.2 TIME SWITCHES
A. Description: Solid-state programmable units with alphanumeric display complying with UL 917.

2.3 PHOTOELECTRIC RELAYS
A. Description: Solid state, with single-pole, double-throw dry contacts rated to operate connected relay or contactor coils or microprocessor input, and complying with UL 773A.

B. Outdoor Sealed Units: Weather tight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.4 OCCUPANCY SENSORS
A. Ceiling-Mounting Units: Unit receives control power from a separately mounted auxiliary power and control unit, and operates power switching contacts in that unit.

B. Switch-Box-Mounting Units: Unit receives power directly from switch leg of the 120- or 277-V ac circuit it controls and operates integral power switching contacts rated 800 W at 120-V ac, and 1000 W at 277-V ac, minimum.

C. Operation: Turns lights on when room or covered area is occupied and off when unoccupied, unless otherwise indicated.

   1. Time Delay for Turning Lights Off: Adjustable over a range from 1 to 30 minutes, minimum.
   2. Isolated Relay Contact: Operates on detection of occupancy or vacancy, as indicated, to activate an independent function.

D. Dual-Technology Type: Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in the field by operating controls on unit.

2.5 MULTIPOLe CONTACTORS AND RELAYS
A. Description: Electrically operated and mechanically held, and complying with UL 508 and NEMA ICS 2.

   1. Current Rating for Switching: UL listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).
   2. Control Coil Voltage: Match control power source.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.

B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 26 Section "Basic Electrical Requirements."

C. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounted devices.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section "Wire and Cables" for low-voltage connections and digital circuits.

B. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes."

C. Bundle, train, and support wiring in enclosures.

D. Ground equipment.

E. Connections: 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.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Electrical Identification."

3.4 FIELD QUALITY CONTROL

A. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.

B. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

C. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.
D. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
   a. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

E. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

F. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

G. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide one Project site visit, when requested, to adjust light levels, make program changes, and adjust sensors and controls to suit actual conditions.

END OF SECTION
SECTION 26 09 43
NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes network lighting control system and components:
   1. Touch panel controls
   2. Lighting management panels
   3. Lighting management modules
   4. Low voltage wall stations
   5. Power interfaces
   6. Wired sensors

B. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.

C. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed). Specific dimmers will be capable of “dimming lights to off”.

D. All system devices shall be networked together, enabling digital communication between devices, and shall be individually addressed.

E. 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.

F. The system architecture shall facilitate remote operation via a computer connection.

G. The system shall not require any centrally hardwired switching equipment.

H. The system shall be capable of wireless, wired, or hybrid wireless/wired architectures.

1.3 DEFINITIONS

A. BACnet: A networking communication protocol that complies with ASHRAE 135.

B. BAS: Building Automation system.

C. 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.

D. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, manual switches and plates, and conductors and cables.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
3. Riser Diagrams – typical per room type (detailed drawings showing device interconnectivity of devices).
4. Other Diagrams – as needed for special operation or interaction with other system(s).
5. Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

B. Field quality-control reports.

C. Hardware and Software Operation Manuals.

D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

E. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Provide a factory published manual including normal operation, emergency operation, and maintenance requirements.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.

B. Manufacturer: Minimum 10 years of experience designing and assembling architectural lighting controls

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. All components and the manufacturing facility where product was manufactured must be RoHS compliant.

E. In high humidity or cold environments, the sensors shall be conformably coated and rated for condensing humidity and -40 degree Fahrenheit (and Celsius) operation.

F. Comply with 47 CFR, Subparts A and B, for Class A digital devices.

G. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.
   1. Match components and interconnections for optimum performance of lighting control functions.
   2. Coordinate lighting controls with BAS. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
   3. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
   4. Coordinate placement of daylight and occupancy sensors to achieve optimum performance. Proper sensor placement should be coordinated with others in order to avoid obstructions that would interfere with maintaining prescribed light levels
   5. Coordinate the work to provide luminaires and lamps that are compatible with the lighting controls to be installed
   6. Coordinate location of touch panels and keypad stations with finish work that is to be installed by others
   7. Notify architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work

B. Pre-installation meeting: Conduct on-site meeting with lighting control representative prior to starting work as part of manufacturer’s standard startup service. Representative to review with the installer:
   1. Low voltage wiring requirements
   2. Line voltage and low voltage separation requirements
   3. Lighting management panel locations
   4. Sensor locations
   5. Touch Panel locations
   6. Keypad locations
   7. Wall station locations
   8. Networked luminaire wiring requirements
   9. Connections to other equipment
C. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards."

1.9 PROJECT CONDITIONS

A. Only install equipment after the following site conditions are maintained:
   1. Ambient Temperature 14 to 105 degrees F (-10 to 40 degrees C).
   2. Relative Humidity less than 90% non-condensing.

B. Standard electrical enclosures are permanently installed.

C. Equipment is protected from dust, debris and moisture.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.

   1. Failures include, but are not limited to, the following:
      a. Failure of software input/output to execute switching or dimming commands.
      b. Failure of modular relays to operate under manual or software commands.
      c. Damage of electronic components due to transient voltage surges.

   2. Warranty Period: Five (5) years from date of Substantial Completion.

1.11 MAINTENANCE & SUSTAINABILITY

A. Provide new parts, upgrades, and/or replacements available for a minimum of five (5) years available to the end user.

B. Provide free telephone technical support.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Network lighting control system has been designed around:

   1. Acuity Brands Lighting, Inc. – System: nLight and Fresco by Acuity Controls.

B. Other Manufacturers: Other manufacturers meeting all requirements of lighting control drawings and specifications will be considered acceptable on an as equal basis if approved by Engineer and Owner.

   1. All substitutions must be submitted for approval prior to bid date.
   2. Proposed substitute products must be documented with a line by line compliance review.

C. Other acceptable manufacturers:

   1. Intelligent Lighting Controls.
2.2 SYSTEM REQUIREMENTS

A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.

B. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.

1. Hardwired Points:
   b. Control: On-off operation.

2. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

C. Plenum Rated: All devices and cabling located above ceilings shall be plenum rated.

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 so as 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 Networked LED Luminaire section).

G. Intelligent lighting control devices shall communicate digitally, require <7 mA of current to function (Graphic wall stations excluded), and possess RJ-45 style connectors.

H. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.

I. Devices within a lighting control zone shall be connected with CAT-5e low voltage cabling in any order.
J. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

K. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

L. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, controls enabled luminaires, or from the network backbone. Standalone "bus power supplies" shall not be required in all cases.

M. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

N. System shall have one or more primary wall mounted network control “gateway” devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.

O. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.

P. System shall be capable of wirelessly connecting a lighting zone to a WiFi (802.11n) wireless data network for purposes of eliminating the “bridge” devices and all cabling that connects zones to bridge devices.

Q. WiFi enabled devices shall be able to detect when WiFi network is down and revert to a user directed default state.

R. WiFi-enabled devices shall be capable of current monitoring

S. WiFi-enabled devices shall utilize WPA2 AES encryption

T. WiFi-enabled devices shall be able to connect to 802.11b/g/n WiFi networks

U. WiFi-enabled devices shall have two local RJ-45 port for communicating with non WiFi-enabled system devices

V. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control schedules and profiles.

W. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

X. Devices located in different lighting zones shall be able to communicate occupancy, photocell (non-dimming), and switch information via either the wired or WiFi backbone.

Y. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time

Trinity Valley Community College
Health Science Center
RSA Project No. 1707.00
December 29, 2017

NETWORK LIGHTING CONTROLS
50% CD’S / GMP Pricing
schedule so as to enable customized time-of-day, day-of-week, utilization of a space. Note: Operating modes should be utilized only in manners consistent with local energy codes.

1. Auto-On / Auto-Off (via occupancy sensors)
   - Zones with occupancy sensors automatically turn lights on when occupant is detected.
   - Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
   - Pressing a switch will turn lights off. The lights will remain off regardless of occupancy until switch is pressed again, restoring the sensor to Automatic On functionality.

2. Manual-On / Auto-Off (also called Semi-Automatic)
   - Pushing a switch will turn lights on.
   - Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.

   - Pushing a switch will turn lights on.
   - After initial lights on, zones with occupancy and/or photocell sensors turn lights on/off according to occupancy/vacancy and/or daylight conditions.
   - Sequence can be reset via scheduled (ex. daily each morning) events.

4. Auto-to-Override On
   - Zones with occupancy sensors automatically turn lights on when occupant is detected.
   - Zone lighting then goes into an override on state for a set amount of time, or until the next time event returns the lighting to an auto-off style of control.
   - Sequence can be reset via scheduled (ex. daily each morning) events.

5. Manual-to-Override On
   - Pushing a switch will turn lights on.
   - Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
   - Sequence can be reset via scheduled (ex. daily each morning) events.

6. Auto On / Predictive Off
   - Zones with occupancy sensors automatically turn lights on when occupant is detected.
   - Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
   - Pressing the switch will turn the lights off and a short “exit timer” begins. After the timer expires, sensor scans the room to detect whether occupant is still present. If no occupancy is detected, zone returns to auto-on. If occupancy is detected, lights must be turned on via the switch.

7. Multi-Level Operation (multiple lighting levels per manual button press)
   - Operating mode designed specifically for bi-level applications.
   - Enables the user to cycle through up to four potential on/off/dim low/dim high lighting states using only a single button.
   - Eliminates user confusion as to which of two buttons controls which load.
   - Three different transition sequences are available in order to comply with energy codes or user preference.
   - Mode available as a setting on all devices that have single manual on/off switch (ex. nPODM, nPODM-DX, nWSX LV).
   - Depending on the sequence selected, every button push steps through relay/dimming states according to below table.
   - In addition to achieving bi-level lighting control by switching loads with relays, the ability to command dimming outputs to "step" in a sequence that achieves bi-level operation is present.
Z. A taskbar style desktop application shall be available for personal lighting control.

AA. An application that runs on “smart” handheld devices (such as an Apple® IPhone®) shall be available for personal lighting control.

BB. Control software shall enable logging of system performance data and presenting this information in a web-based format and downloadable to .CSV files.

CC. Control software shall enable integration with a BMS via BACnet IP, although a hardware BACnet IP integration solution is also available.

DD. System shall provide the option of having pre-terminated plenum rated CAT-5e cabling supplied with hardware.

EE. Fresco System Specific Requirements:
   2. Luminaire Compatibility: Supports RGB luminaires in 8 bit and/or 16 bit configurations also supporting MSB or LSB first luminaire settings.
   3. Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
   4. Power Failure Memory: automatically store system settings and recover from a power failure without requiring user input.
   5. Wireless devices:
      a. Automatically sync for system operation without addressing
b. Send and receive messages for real-time operation and feedback

c. Use industry standard RF protocols

d. Be in compliance with FCC and IEE standards

6. Time Clock: automatically adjust for daylight savings time and leap year.

FF. Fresco System Specific Dimming and Switching Performance Requirements:

1. Electrolytic capacitors operate at least 36 degrees F (20 degrees C) below the capacitor's maximum temperature rating when the device is under full load

2. Inrush tolerance: Use MOSFET that has a maximum rating of six times the operating current of the dimmer/relay

3. Surge tolerance: Panels are designed and tested to withstand surges of 6,000V, 3,000amps according to IEEE C62.41.2 and IEC 61000-4-5 without impairment to performance

4. Power failure recovery: When power is interrupted and subsequently restored, within 3 seconds lighting to automatically return to same levels prior to power failure

5. Utilize half cycle to half cycle zero cross movement to allow for voltage compensation in order to overcome line noise and lamp flickering

6. Incorporate electronic soft start default at initial turn-on that smoothly ramps lights to appropriate levels within 0.5 seconds

7. Utilize air gap off to disconnect the load line from the line supply

8. Control all light sources in smooth and continuous manner. Dimmers with visible steps are not acceptable

9. Assign load type to each dimmer that will provide proper dimming curve for the specific light source to be controlled

10. Minimum and maximum light levels are user adjustable on a circuit by circuit basis

2.3 INDIVIDUAL DEVICE SPECIFICATIONS (nLIGHT SYSTEM)

A. Control module (gateway)

1. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet network.

2. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.

3. Control device shall have three RJ-45 ports for connection to the graphic touch screen, other backbone devices (bridges) or directly to lighting control devices (up to 128 per port).

4. Device shall automatically detect all devices downstream of it.

5. Device shall have a standard and astronomical internal time clock.

6. Device shall have one RJ-45 10/100 BaseT Ethernet connection.

7. Device shall have a USB port

8. Each control gateway device shall be capable of linking 1500 devices to the management software, with reduced memory version capable of support up to 400 devices.

9. Device shall be capable of using a dedicated static or DHCP assigned IP address.

10. Network Control Gateway device shall be the following nLight model Series:
    a. nGWY2

B. Networked system occupancy sensors

1. Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.

2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional “dual” technology shall be used.

4. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.

5. All sensing technologies shall be acoustically passive, meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.

6. Sensors shall be available with zero or one integrated dry contact switching relays, capable of switching 1 amp at 24 VAC/VDC (resistive only).

7. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.

8. Sensors shall be available in multiple lens options which are customized for specific applications.

9. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

10. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.

11. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue.

12. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

13. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.

14. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.

15. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.

16. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

17. Wall switch sensors shall have optional features for photocell/daylight override, and low temperature/high humidity operation.

18. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)

19. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.

20. Wall switch sensors shall be the following nLight model numbers, with device color and optional features as specified:
   a. nWSX (PIR, 1 Relay)
   b. nWSX PDT (Dual Tech, 1 Relay)
   c. nWSX LV (PIR, No Relay)
   d. nWSX PDT LV (Dual Tech, No Relay)
   e. nWSX LV NL (PIR w/ Night Light, No Relay)
   f. nWSX PDT LV NL (Dual Tech w/ Night Light, No Relay)
   g. nWSX LV DX (PIR, No Relay, Raise/Lower Dim Ctrl)
21. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.

22. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection.

23. Embedded sensors shall have an optional photocell.

24. Embedded sensors shall be the following nLight model number:
   a. nES 7 (PIR, No Relay)
   b. nES 7 ADCX (PIR w/ Photocell, No Relay)
   c. nES PDT 7 (Dual Technology, No Relay)
   d. nES PDT 7 ADCX (Dual Technology w/ Photocell, No Relay)

25. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.

26. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.

27. Sensors shall be the following nLight model numbers, with device options as specified in table below.
### Model # Series

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<thead>
<tr>
<th>Model # Series</th>
<th>Occupancy Poles</th>
<th># of Relays</th>
<th>Lens Type</th>
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### C. Networked system daylight (photocell and/or dimming) sensors.

1. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
2. Photocell and dimming sensor’s set-point and deadband shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.

3. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).

4. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements. (Note: This function should be performed prior to any dimming of the lamps including the “auto set-point” setting.)

5. Combination units that have all features of on/off photocell and dimming sensors shall also be available.

6. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an “offset” from the primary zone.

7. Sensor shall be the following nLight model numbers, with device options as specified:
   a. nCM(B) PC (RJB) (on/off)
   b. nCM(B) PC DZ (RJB) (on/off control, dual zone)
   c. nCM(B) ADCX (RJB) (remote automatic dimming control photocell)
   d. nCM(B) ADCX DZ (RJB) (remote automatic dimming control photocell, dual zone)
   e. nRM PC (on/off)
   f. nRM PC DZ (on/off, dual zone)
   g. nRM ADCX (remote automatic dimming control photocell)
   h. nRM ADCX DZ (remote automatic dimming control photocell, dual zone)

8. Network system shall have dimming photocells that can be embedded into luminaire such that only the lens shows on luminaire face.

9. Embedded sensors shall be the following nLight model number:
   a. nES ADCX (Dimming Photocell)

D. Networked System Power (Relay) Packs

1. Power Packs shall incorporate one Class 1 relay, a 0-10 VDC dimming output, and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.

2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.

3. All devices shall have two RJ-45 ports.

4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.

5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

7. Power Packs and Power Supplies shall be available that are WiFi enabled.
8. Power Packs (Secondary) shall be available that provide up to 16 Amp switching of all lighting load types.
9. Power Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.
10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120/277 VAC magnetic low voltage transformers.
12. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC electronic low voltage transformers.
13. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
14. Specific Secondary Packs shall be available that control louver/damper motors for skylights.
15. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.
16. Power (Secondary) Packs shall be available that provide up to 20 Amps switching of general purposed receptacle (plug-load) control.
17. Power (Relay) Packs and Supplies shall be the following nLight model numbers:
   a. nPP16 (Power Pack w/ 16A relay)
   b. nPP16 D (Power Pack w/ 16A relay and 0-10VDC dimming output)
   c. nPP16 WIFI (Power Pack w/ 16A relay, WIFI enabled)
   d. nEPP5 D (Power Pack w/ 5A relay and 0-10VDC dimming output) nSP16 (Secondary Pack w/ 16A relay)
   e. nPP16 ER (UL924 Listed Secondary Pack w/ 16A relay for switching emergency power circuits)
   f. nPP16 D ER UL924 Listed Secondary Pack w/ 16A relay and 0-10VDC dimming output for switching/dimming emergency power circuits)
   g. nSP5 PCD ELV 120 (Secondary Pack w/ 4A relay and electronic low voltage dimming output)
   h. nSP5 2P LVR (Louver/Damper Control Pack)
   i. nSHADE (Pulse On/Off Control Pack)
   j. nPP20 PL (Secondary Pack w/ 20A relay for general purpose receptacle load)
   k. nPS 80 (Auxiliary Bus Power Supply)
   l. nPS 80 WIFI (Auxiliary Bus Power Supply, WiFi enabled)
   m. nAR 40 (Low voltage auxiliary relay pack)

E. Networked System Relay & Dimming Panels
1. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.
2. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
3. Panel shall provide one 0-10VDC dimming output paired with each relay.
4. Panel shall power itself from an integrated 120/277 VAC supply.
5. Panel shall be capable of operating as either two networked devices or as one.
6. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection.
8. Power (Relay) Packs and Supplies shall be the following nLight model numbers:
   a. nPANEL 4 (Panel w/ four 120/277 VAC relays and four 0-10 VDC dimming outputs)
   b. nPANEL 2 480 (Panel w/ two dual phase relays (208/240/480 VAC) and two 0-10 VDC dimming outputs)
F. Networked Auxiliary Input / Output (I/O) Devices
1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
2. Devices shall have two RJ-45 ports
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current.
5. Specific I/O devices shall have an input that reads a 0-10 VDC signal from an external device.
6. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event (toggle the lighting load) or run a local/remote control profile.
7. Specific I/O devices shall sense state of low voltage outdoor photocells.
8. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based AV control systems.
9. Specific I/O devices shall sense momentary and maintained contact closures, and either toggle a connected load after a momentary contact or ramp the load high/low during a maintained contact (stopping when the contact releases).
10. Auxiliary Input/Output Devices shall be the following nLight model numbers:
   a. nIO D (I/O device with 0-10 dimming output)
   b. nIO 1S or nIO RLX (I/O device with contact closure or 0-10VDC dimming input)
   c. nIO NLI (Input device for detecting state of low voltage outdoor photocell; sold in nIO PK KIT only)
   d. nIO X (Interface device for communicating with RS-232 enabled AV Touch Screens

G. Networked LED Luminaires
1. Networked LED luminaire shall have a mechanically integrated control device
2. Networked LED luminaire shall have two RJ-45 ports available (via control device directly or incorporated RJ-45 splitter)
3. Networked LED luminaire shall be able to digitally network directly to other network control devices (sensors, photocells, switches, dimmers)
4. Networked LED luminaire shall provide low voltage power to other networked control devices (excluding EMG versions)
5. System shall be able to turn on/off specific LED luminaires without using a relay, if LED driver supports "sleep mode"
6. System shall be able to maintain constant lumen output over the specified life of the LED luminaire (also called lumen compensation) by varying the input control power (and thus saving up to 20% power usage).
7. System shall indicate (via a blink warning) when the LED luminaire has reached its expected life (in hrs).
8. Integrated control devices shall be the following nLight model series:
   a. nIO LEDG (ER)
   b. nIO EZ PH (ER)
   c. nPS 80 EZ (ER)
   d. nEPS 60 IO EZ
   e. nEIO EZ LC (ER)
9. LED Luminaires shall be the following Acuity Brands LED fixtures, which come factory enabled with nLight devices:
   a. Lithonia model families:
      1) RTL(X)
      2) TL(X)
3) VTL(X)
4) FSL(X)
5) ACL(X)
6) ALL(S)
7) AVL
8) BZL
9) GTL
10) SBS
11) IBL/IBH
12) PTN
13) LDN
14) DOM
15) WL
16) STL

b. Gotham model families:
   1) EVO
   2) Incito

c. Mark model families:
   1) Slot 2/4/6
   2) Fin
   3) Veil
   4) Whisper
   5) Nol
   6) SPR

d. Peerless model families:
   1) Vellum
   2) Mino
   3) Round 2/4
   4) Square
   5) Origami
   6) Bruno
   7) Staple
   8) Lightline
   9) Lightedge
   10) Icetray
   11) Cerra
   12) Prima
   13) Naro
   14) Tulip
   15) Envision
   16) Aero
   17) Enzo

H. Networked System Wall Switches & Dimmers
1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
3. All devices shall have two RJ-45 ports.
4. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
5. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
6. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
7. Devices with mechanical push-buttons shall be made available with custom button labeling.
8. Devices with a single “on” button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.

9. Wall switches & dimmers shall be the following nLight model numbers, with device options as specified:
   a. nPODM (single on/off, push-buttons, LED user feedback)
   b. nPODM DX (single on/off, single dimming raise/lower, push-buttons, LED user feedback)
   c. nPODM 2P (dual on/off, push-buttons, LED user feedback)
   d. nPODM 2P DX (dual on/off, dual dimming raise/lower, push-buttons, LED user feedback)
   e. nPODM 4P (quad on/off, push-buttons, LED user feedback)
   f. nPODM 4P DX (quad on/off, quad dimming raise-lower, push-buttons, LED user feedback)

I. Networked System Graphic Wall Station
1. Device shall have a 3.5” full color touch screen for selecting up to 16 programmable lighting control preset scenes or acting as up to 16 on/off/dim control switches.
2. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
3. Device shall enable configuration of all switches, dimmers, and lighting preset scenes via password protected setup screens.
4. Device shall enable user supplied .jpg screen saver image to be uploaded.
5. Device shall surface mount to single-gang switch box.
6. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.
7. Device shall have a micro-USB style connector for local computer connectivity.
8. Device shall have two RJ-45 ports for communication
9. Device shall be the following nLight model number:
   a. nPOD GFX

J. Networked System Scene Controllers
1. Device shall have two, three, four, or eight buttons for selecting programmable lighting control profiles or acting as on/off switches.
2. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
3. Device shall recess into single-gang switch box and fit a standard GFI opening.
4. Devices shall provide LED user feedback.
5. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
6. All devices shall have two RJ-45 ports.
7. Device shall be capable of reprogramming other devices in its zone so as to implement user selected lighting scene.
8. Device shall be capable of selecting a lighting profile be run by the system’s upstream Gateway so as to implement selected lighting profile across multiple zones (and not just its local zone).
9. Device shall have LEDs indicating current selection.
10. Scene Selector device shall be the following nLight model number:
    a. nPODM 2S (2 Scene, push-button)
    b. nPODM 4S (4 Scene, push-button)
    c. nPODM 4S DX (4 Scene, push-button, On/Off/Raise/Lower)
    d. nPODM 2L (2 Adjustable Preset Levels, push-button, On/Off)
    e. nPODM 2L AB (2 Scene, push-button, On/Off/High/Low)
    f. nPODM 4L DX (4 Adjustable Preset Levels, push-button, On/Off/Raise/Lower)
K. Communication Bridges
1. Device shall surface mount to a standard 4” x 4” square junction box.
2. Device shall have 8 RJ-45 ports.
3. Device shall be capable of aggregating communication from multiple lighting control
zones for purposes of minimizing backbone wiring requirements back to Control
Gateway.
4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired
power supply or delivered via a CAT-5 cabled connection.
5. Device shall be capable of redistributing power from its local supply and connect lighting
control zones with excess power to lighting control zones with insufficient local power.
This architecture also enables loss of power to a particular area to be less impactful on
network lighting control system.
6. Communication Bridge devices shall be the following nLight model numbers:
   a. nBRG 8 (8 Ports)

2.4 INDIVIDUAL DEVICE SPECIFICATIONS (FRESCO SYSTEM)

A. Touch Panel Controls
   Product: Fresco Touch Screen (7TSN)
   Preset lighting scene controller
1. General Requirements:
   a. 7” full color multi-touch capacitive touchscreen for controlling lighting and system
      components
   b. Control up to 36 dynamic lighting zones/scenes per touch screen
   c. Link up to 8 touch screens for a possibility of 288 lighting zones/scenes
   d. Connect up to 128 network devices per touch screen
   e. On screen lighting design
   f. Lighting zones/scenes can be comprised of lighting intensity, color, color
      temperature, and luminaire position
   g. Modify color and color temperature using a digital color palette and UV rating scale
   h. Proximity screen sensor for auto “wake-up”
   i. Auto dimming and user adjustable backlight
   j. User programmable screen lock limiting access to all feature control and
      programming
   k. Full alpha-numeric scene and zone naming
   l. Configurable interface to reflect project requirements
   m. Lighting zones/scenes support control of forward/reverse phase dimming, 0-10v,
      RGB, nLight® enabled luminaires, nLight® power packs, DALI, tunable white and
      moving fixtures
   n. Integral astronomical time clock enables lighting scenes
   o. Partition status control and visualization
   p. Direct DMX control for a single universe (512 slots)
   q. Connect up to 128 nLight® enabled devices
   r. Digital motion sensor control
   s. Digital daylight harvesting response
   t. RS-232/contact closure capable for 3rd party integration
   u. Local wireless Bluetooth connectivity with mobile app
   v. Compatible with Fresco Lighting Management Panels (LMP)
   w. Frame Color: {Black} {Aluminum} {White} (Custom) Coordinate color selection with
      Architect.
2. Electrical:
   a. Fresco Input: 24VDC
   b. Fresco Power Supply: 120/277V AC
c. RS-485 network terminal
d. nLight enabled RJ-45 ports (in/out)
e. {CAT5e Ethernet network terminal}
f. {DMX/RDM network terminal}

3. Mounting:
   a. Installs in a standard triple gang US back box
   b. Remote mounted power supply
   c. Plug in wire harness for RS-485 and DMX connections

4. Protocols:
   a. RS-485
   b. IEEE 802.15 Bluetooth® compliant
   c. {Controller is compliant to industry standard ANSI E1.11 - 2008, USITT DMX512-A}
d. {Supports extended RDM capability as defined by ANSI E1.20}
   e. {IEEE 802.11 Ethernet compliant}
f. nLight Digital communication

B. Mobile Control
   Fresco iPad Application
   Allows mobile control and programming of the Fresco Touchscreen (7TSN)
   1. General Requirements:
      a. Mobile Apple device supports Bluetooth® communication protocol
      b. Provides user control and edit capability of lighting scenes and zones
      c. Edit intensity, color, color temperature, and movement
      d. Edit lighting schedules
      e. Restrict number of users able to connect to touchscreen
      f. Restrict access to making system changes
      g. No PC required for mobile operation

C. Lighting Management Panels
   Product: Fresco Lighting Management Panel (FCS LMP)
   1. General Requirements:
      a. Comply with UL508
      b. Universal voltage operation 120V-277V (MVOLT)
      c. Available as {Factory-assembled} or {Rough-in enclosure}
      d. Available as {Feed-Through} {4-wire Main Lug} {3-wire Main Lug}
      e. Configurable for site conditions with certain modules and circuit breakers {small} {medium} {large}
      f. Oversized field wiring channel to separate line voltage and low voltage
      g. Available voltage barrier
      h. Locking breaker cover
      i. Convection cooled, no fans required
      j. Available with UL924 listed phase loss sensor device (FCS LMPE)
   2. Factory installed bypass circuit jumpers on each dimming circuit.
   3. Provide main lugs and branch circuit protection for each power module unless panel is dedicated as feed-through type
   4. Branch circuit rating
      a. 120V: 2,000W (20A)
      b. 277V: 2,700W (10A)
   5. Branch circuit breakers (when supplied) UL listed thermal magnetic
      a. 120V: 14kAIC
      b. 277V: 14kAIC
   6. Integrated LCD push button controller for addressing panels, system override, modules and systems diagnostics
7. Integral USB port for PC based panel programming which is accessible behind locking door
8. Mounting: Recessed or surface mounted NEMA type 1 enclosure

D. Panel Installed Lighting Management Modules
Product: LM4A MVOLT
4 channel phase adaptive dimming module
1. General Requirements:
   a. Compatible lighting loads: incandescent, magnetic low voltage, electronic low voltage, 2 and 3 wire fluorescent, forward and reverse phase LED dimming
   b. Phase independent
   c. Power management reports status and power consumption
   d. Zero minimum load required
   e. Load types are configured per channel
   f. 165µ rise and fall times
   g. Field replaceable without requiring re-programming
2. Ratings:
   a. Module: 16A maximum at 120V~/10A maximum at 277~
   b. Channel: 8A continuous at 120V~/5A continuous at 277V~

Product: LM4D MVOLT
4 channel phase selectable dimming module
3. General Requirements:
   a. Compatible lighting loads: forward and reverse phase LED dimming module for electronic low voltage, 2 wire fluorescent and LED lighting
   b. Phase independent
   c. Zero minimum load required
   d. Load types are configured per channel
   e. 50µ rise and fall times
4. Ratings:
   a. Module: 16A maximum at 120V~/10A maximum at 277V~
   b. Channel: 8A continuous at 120V~/5A continuous at 277V~

Product: LM4L MVOLT
4 channel 0-10v dimming module with mechanically latching relays
5. General Requirements:
   a. Compatible with 0-10V load types that are IEC60929 compliant
   b. 50A mechanically latching relays
6. Ratings:
   a. 0-10V: 25mA maximum
   b. Relay: 16A continuous at 120V~/16A continuous at 277V~

Product: LM2B MVOLT
Dual Loop DALI Controller
7. General Requirements:
   a. Digital ballast/LED driver controller
   b. Compatible with DALI load types that are IEC60929 compliant
   c. 2 DALI loops (64 ballasts/drivers max per loop)
   d. Integrated DALI bus power supply supplies power to loops
8. Ratings:
   a. DALI: 150mA maximum

Product: LM4R MVOLT
4 channel relay module
9. General Requirements:
   a. 50A rated relay per channel with override switch
   b. Suitable for switching compatible non dimming lighting loads

10. Ratings:
    a. Relay: 16A continuous at 120V~/16A continuous at 277V~

E. Low Voltage Wall Stations
Product: nPOD (nLight ®)
Push button lighting scene controller

1. General Requirements:
   a. Use Cat5 wiring with RJ45 adapters for connection between devices
   b. Recess into single gang junction box
   c. Allows control of any lighting fixtures part of the lighting control system
   d. Upon button press, LED to immediately illuminate
   e. Controller can be setup as scene recall, toggle, or raise/lower
   f. Controller station LED’s track system status logic
   g. Replacement of unit does not require reprogramming
   h. Allows connection to additional stations, sensors, or power packs
   i. Custom button engraving
   j. Colors {White}{Almond}{Lt Almond}{Gray}{Black}. Coordinate color selection with Architect.

F. Remote Mounted Power Modules
Networked relay and dimming power packs

1. Products: (nLight ®)
   a. nPP16 (Power pack with 16A relay)
   b. nEPP5D (Power pack with 5A relay and 0-10VDC output)
   c. nSP16 (Secondary power pack with 16A relay)
   d. nSP52P (Secondary power pack with 2 5A relays)
   e. nSP5D (Secondary power pack with 5A relay and 0-10VDC dimming output)
   f. nPP16ER (UL924 listed secondary power pack with 16A relay for switching emergency lighting circuit
   g. nSP5PCDMLV (Secondary power pack with 5A relay and magnetic low voltage dimming output)
   h. nSP5PCDELV (Secondary power pack with 5A relay and electronic low voltage dimming output)

2. General Requirements:
   a. Power pack will incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system
   b. Secondary power packs incorporate the relay(s), 0-10VDC dimming output, or line voltage dimming output
   c. Accept 120/277VAC and plenum rated
   d. All devices have two RJ-45 ports
   e. Parameters available and configurable remotely from software and locally via device push-button
   f. Power pack to be securely mounted to junction box with ½ inch threaded chase nipple or mounted within luminaire ballast channel
   g. Power (secondary) packs that provide up to 16A switching of all load types
   h. 8Power (secondary) packs that provide up to 5A switching of all load types as well as 0-10VDC dimming or fluorescent ballasts/LED drivers
   i. Specific secondary packs provide up to 5A of switching and can dim 120VAC incandescent or 120/277VAC line voltage dimmable fluorescent (2-wire and 3-wire versions)
j. Specific secondary packs provide up to 5A of switching and can dim 120/277VAC magnetic low voltage transformers  
k. Specific secondary packs provide up to 5A of switching and can dim 120VAC electronic low voltage  
l. Specific power/secondary are UL924 listed for switching of emergency power circuits  

G. Digital Sensors  
1. Wired Networked Occupancy/Vacancy Sensors/Photocells  
2. Products: Network Wall Switch Sensors  
a. nWSD or nWSX (PIR, 1 Relay)  
b. nWSD PDT or nWSX PDT (Dual Tech, 1 Relay)  
c. nWSD NL (PIR w/Night Light, 1 Relay)  
d. nWSD PDT NL (Dual Tech w/Night Light, 1 Relay)  
e. nWSX NL LV (PIR w/Night Light, No Relay)  
f. nWSD PDT NL LV (Dual Tech w/Night Light, No Relay)  
g. nWSD LV or nWSX LV (PIR, No Relay, Raise/Lower Dim Control)  
h. nWSD PDT LV or nWSX PDT LV (Dual Tech w/Night Light, No Relay, Raise/Lower Dim Control)  
3. Products: Network Fixture Embedded Sensors  
a. nES 7 (PIR, No Relay)  
b. nES 7 ADCX (PIR w/Photocell, No Relay)  
c. nES PDT 7 (Dual Tech, No Relay)  
d. nES PDT 7 ADCX (Dual Tech w/Photocell, No Relay)  
e. nES ADCX (Dimming photocell)  
4. Products: Network Standard Range 360° Ceiling Mount Sensors  
a. nCMRPDT9 (Low Voltage, Dual Tech)  
b. nCMRPDT9 (Line Voltage, Dual Tech)  
c. nCMR92P (Line Voltage, PIR, 2-Pole)  
d. nCMRPDT92p (Line Voltage, Dual Tech, 2-Pole)  
e. nCM92P (Low Voltage, PIR, 2 Channels)  
f. nCM9 (Line Voltage, PIR)  
g. nCM9 (Low Voltage, PIR)  
h. nCMRPDT92P (Low Voltage, Dual Tech, 2 Channels)  
5. Products: Network Standard Range 360° Recessed Mount Sensors  
a. nRM9 (Low Voltage, PIR)  
b. nRM9 (Low Voltage, PIR)  
c. nRM9 (Line Voltage, PIR)  
d. nRM9 (Low Voltage, PIR)  
e. nRM9 (Line Voltage, PIR)  
f. nRM92P (Low Voltage, 2 Channels)  
g. nRMPDT92P (Low Voltage, Dual Tech, 2 Channels)  
6. Products: Network Standard Range 360° Fixture Mount Sensors  
a. nCMRB9 (Line Voltage, PIR)  
b. nCMBJ9 (Line Voltage, PIR)  
c. nCMRB9 (Low Voltage, PIR)  
d. nCMRB9 (Low Voltage, PIR)  
e. nCMRB9 (Line Voltage, Dual Tech)  
f. nCMRB9 (Line Voltage, Dual Tech)  
g. nCMRB9 (Low Voltage, PIR)  
h. nCMRB9 (2 Channels)  
7. General Requirements  
a. Occupancy sensors sense presence of human activity within the desired space and control on/off function of the lights
b. Utilize passive infrared (PIR) technology which detects occupant motion

c. Sensors are available for ceiling, wall, corner, recessed, and fixture mounting conditions

d. Dual technology sensors utilize PIR/Microphonics (also known as Passive Dual Technology or PDT)

e. Sensors utilizing Microwave or Ultrasonic technology will not be accepted

f. Sensors are available with zero, one, or two Class 1 switching relays, and up to one 0-10VDC dimming output.

g. Provide multiple lens options which are interchangeable for specific applications

h. Communication and Class 2 low voltage power is delivered to each device with CAT-5 cabling and terminate with RJ-45 connectors

i. All sensors have two RJ-45 ports for purpose of daisy chain wiring method

j. Sensors are equipped with automatic override for 100 burn-in of lamps

k. Wall switch sensors have optional features for photocell/daylight override, vandal resistant, and low temperature/high humidity option

l. Sensors capable of being embedded into luminaire

m. Photocells provide on/off set-point and deadband to prevent artificial light from cycling

n. Photocell and dimming sensor set-point is automatically calibrated using sensor microprocessor

o. Photocell min/max thresholds may be manually configured

p. Dimming sensors control 0-10VDC dimmable ballasts by sinking up to 20mA of Class 2 current

2.5 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Specific device parameters (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device, with a system backup on the software’s host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.
J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.6 MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.

E. A printable report detailing all system profiles shall be available via the software.

F. Software shall require all users to login with a User Name and Password.

G. Software shall provide at least three permission levels for users.

H. All sensitive stored information and privileged communication by the software shall be encrypted.

I. All device firmware and system software updates must be available for automatic download and installation via the internet.

J. Software shall be capable of managing systems interconnected via a WAN (wide area network)

2.7 BMS COMPATIBILITY

A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software.

B. BACnet IP connection shall also be available utilizing JACE-600 hardware unit.

C. BACnet IP hardware shall be capable of supporting up to 1500 total devices across up to 5 total Gateways.

D. BACnet IP connection shall communicate information gathered by networked system to other building management systems.

E. BACnet IP connection shall translate and forward lighting relay and other select control commands from BMS system to networked control devices via profiles stored in the system Gateway. All system devices shall be available for polling for devices status.

F. BACnet IP hardware device shall be the following nLight model name:

1. nBACnet
2.8 SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE

A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.

B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.

C. An “Energy Scorecard” shall be displayed that shows calculated energy savings in dollars, KWHr, or CO2.

D. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc).

E. Energy savings data shall be calculated for the system as a whole or for individual zones.

F. A time scaled graph showing all relay transitions shall be presented.

G. A time scaled graph showing a zone's occupancy time delay shall be presented.

H. A time scaled graph showing the total light level shall be presented.

I. User shall be able to customize the baseline run-time hours for a space.

J. User shall be able to customize up to four time-of-day billing rates and schedules.

K. Data shall be made available via a .CSV file.

2.9 START-UP & SUPPORT FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.

B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. All system devices shall be capable of being given user defined names.

E. All devices within the network shall be able to have their firmware upgraded remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

F. All sensor devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.
B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 26 Section "Basic Electrical Requirements."

3.2 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install wiring in raceways except where installed in accessible ceilings. Minimum conduit size shall be 3/4 inch (13 mm).

1. For power wiring comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables"

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

D. Ground equipment.

E. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

F. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

G. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

H. Follow manufacturer's instructions for all installation steps.

I. Properly terminate all DMX wiring per installation instructions.

J. Use only recommended DMX cable and follow local codes.

K. Properly terminate all CAT5 wiring per installation instructions.

L. Properly terminate all RS-485 connections per installation instructions.

M. Connections: 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.

N. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Test for circuit continuity.
2. Verify that the control module features are operational.
3. Check operation of local override controls.
4. Test system diagnostics by simulating improper operation of several components selected by Architect.

D. Lighting controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.5 SOFTWARE INSTALLATION

A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and provide software training for network lighting control system. See Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 26 22 13
TRANSFORMERS

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 types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.

1.3 ACTION SUBMITTALS
A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS
A. Source quality-control test reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.7 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
   2. General Electric Company.
   4. Square D Co./Groupe Schneider NA; Schneider Electric.
   5. Powersmiths

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Gray ANSI 49 gray or ANSI 61 gray.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

G. Harmonic Mitigating Shielded Isolation Transformers:
1. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   a. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   b. Include special terminal for grounding the shield.

H. Energy Efficiency for Transformers Rated 15 kVA and Larger:
1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

I. Sound-Level Requirements: NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

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 C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
A. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

3.3 CONNECTIONS
A. Ground equipment according to Section 260526 "Grounding."
B. Connect wiring according to Section 260519 "Wire and Cables."

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 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.


3.5 CLEANING
A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION
SECTION 26 24 13

SWITCHBOARDS

PART 1   GENERAL

1.1 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. Service and distribution switchboards rated 600 V and less.
   2. Disconnecting and overcurrent protective devices.
   3. Instrumentation.
   4. Control power.
   5. Accessory components and features.
   6. Identification.

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
   6. Detail utility company's metering provisions with indication of approval by utility company.
   7. Include evidence of NRTL listing for series rating of installed devices.
   8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
  10. Include schematic and wiring diagrams for power, signal, and control wiring.
  11. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
12. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for switchboards and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: NETA or an NRTL procedures.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Handle and prepare switchboards for installation according to NECA 400 [NEMA PB 2.1].
1.6 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

1.7 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within specified warranty period.

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. 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. Square D Co.
   2. General Electric Co.
   3. Cutler-Hammer
2.2 SWITCHBOARDS, GENERAL

A. Description: Front-accessible sections, with features as follows:

1. Main Device: Fix mounted.

B. Barriers:

1. Isolation for main bus of main section and main and vertical bus of feeder sections.

2.3 FABRICATION AND FEATURES


B. Front Panels: Allow access to breaker, metering, accessory, and blank compartments.

C. Buses and Connections: Three-phase, four-wire except as otherwise indicated. Features as follows:

2. Ground Bus: 1/4-inch by 2-inch minimum size, hard-drawn copper of 98 percent conductivity, and equipped with pressure connector terminations for feeder- and branch-circuit ground conductors. For busway feeders extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Contact Surfaces of Buses: Silver plated.
5. Main Phase Buses, Neutral Bus, and Equipment Ground Bus: Uniform capacity the entire length of the switchboard main and distribution sections. Provide for future extensions from either end by means of bolt holes or other approved method and connecting links.
6. Neutral Buses: 100 percent of the ampacity of the phase buses except as indicated and equipped with approved pressure connector terminations for outgoing circuit neutral cables. Provide braced neutral bus extensions for busway feeders with neutral conductors.

2.4 INSTRUMENTATION


1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios as indicated and accuracy class suitable for connected relays, meters, and instruments.
3. Control Power Transformers: Dry type. Separate compartments for units larger than 3 kV and their primary and secondary fuses.

4. Current Transformers for Neutral and Ground Fault Current Sensing: Ground/neutral sensor current transformers located as indicated. Connect secondaries to ground overcurrent relays to provide selective tripping of bus tie and main breaker. Coordinate with feeder breaker ground fault protection.

B. Multifunction Digital Metering Monitor: Provide a UL listed microprocessor-based unit suitable for four-wire systems (Square D PM 820 or equal) and with the following features:

1. Inputs: From sensors or current transformers from 100/5 through 5000/5 ratings and potential terminals up to 600 V.

2. Display: Switch selectable digital display of the following values with maximum accuracy tolerances as indicated:

   a. Phase currents, each phase, plus or minus 1 percent.
   b. Phase-to-phase voltages, 3 phase, plus or minus 1 percent.
   c. Phase-to-neutral voltages, 3 phase, plus or minus 1 percent.
   d. Megawatts, plus or minus 2 percent.
   e. Megavars, plus or minus 2 percent.
   f. Power factor, plus or minus 2 percent.
   g. Frequency, plus or minus 0.5 percent.
   h. Megawatt demand with demand interval programmable from 5 to 60 minutes, plus or minus 2 percent.

3. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door on the face of the switchboard at no higher than 65 inches.

C. Handheld Trip Unit Programmer: Provide a handheld unit that is capable of accessing, configuring, testing, and displaying information at the trip unit of each solid state breaker. Unit to be capable of being plugged in directly to the breaker trip unit module.

2.5 RATINGS

A. Provide nominal system voltage, continuous main bus amperage, and short-circuit-current ratings as indicated.

2.6 OVERCURRENT PROTECTIVE DEVICES (OCPDS)

A. Circuit breakers shall be solid state trip furnished with microprocessor-based programmable RMS sensing trip units and full metering and monitoring function.

B. Future Devices: Where provision for future overcurrent protective devices or space is indicated, equip compartments with mounting brackets, supports, bus connections, and necessary appurtenances, designed for the OCPD types and ampere ratings indicated for future installation of devices.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating to meet available fault currents.

   1. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
2. **Current-Limiting Circuit Breakers:** Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

3. **Molded-Case Circuit-Breaker (MCCB) Features and Accessories:**
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
   c. Communication Capability: Where indicated on plans, provide Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
   d. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   e. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   f. Key Interlock Kit: Where indicated on plans, provide externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

D. **Insulated-Case Circuit Breaker (ICCB):** For breakers 1000 amps and larger, furnish 80 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time time adjustments.
   c. Where indicated on plans, provide Ground-fault pickup level, time delay, and I2t response.
4. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
5. Key Interlock Kit: Where indicated on plans, externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.7 **IDENTIFICATION**

A. General: Refer to Division 26 Section "Identification for Electrical Systems." Identify units, devices, controls, and wiring with factory-applied labels and signs.
B. Compartment Nameplates: Engraved laminated plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.

C. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

D. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section “Electrical Noise and Vibration Control.”

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.
G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section “Enclosed Bus Assemblies.” Drawings indicate general arrangement of bus, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

3.5 FIELD QUALITY CONTROL

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

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove panels so joints and connections are accessible to portable scanner.
b. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION
SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 16 Sections apply to this Section:

1. "Basic Electrical Requirements."
2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:

1. "Overcurrent Protective Devices" for circuit breakers, fusible switches, fuses, and other devices used in panelboards.

1.3 DEFINITIONS

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type panelboard, accessory item, and component specified.

C. Shop drawings from manufacturers of panelboards including dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:

1. Enclosure type with details for types other than NEMA Type 1.
2. Bus configuration and current ratings.
4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

D. Panel schedules for installation in panelboards. Submit final versions after load balancing.
E. Maintenance data for panelboard components, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 16 Section "Basic Electrical Requirements." Include instructions for testing circuit breakers.

1.5 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

B. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

C. NEMA Standard: Comply with NEMA PB1, "Panelboards."

D. UL Standards: Comply with UL 61, "Panelboards," and UL 50, "Cabinets and Boxes."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Square D Co.
2. Cutler-Hammer, Co.

2.2 PANELBOARDS, GENERAL REQUIREMENTS

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as indicated. Comply with Division 16 Section "Overcurrent Protective Devices," with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multi-pole breakers shall have common trip.

B. Enclosures: Cabinets, flush or surface mounted as indicated. NEMA Type 1 enclosure.

C. Front: Secured to box with hinges. Front for surface-mounted panels shall be same dimensions as box. Fronts for flush panels shall overlap box except as otherwise specified.

D. Directory Frame: Metal, mounted inside each panel door.

E. Bus: Hard drawn copper of 98 percent conductivity.

F. Main and Neutral Lugs: Compression type.

G. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.

H. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.

I. Hinged Front Cover: Entire front trim hinged to box with standard door within hinged trim cover.
J. Special Features: Provide the following features for all panelboards serving IG ground circuits:

1. Isolated Equipment Ground Busses: Adequate for branch-circuit equipment ground conductors; insulated from box, with a minimum of 42 IG ground cable terminals.

K. Feed-Through Lugs: Compression type, sized to accommodate feeders indicated.

2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch OCPDs: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Double-Width Panels: Where more than 42 poles are indicated or where otherwise indicated, provide two panelboards under single front.

C. Doors: In panel front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike.

2.4 IDENTIFICATION

A. General: Refer to Division 16 Section "Electrical Identification" for labeling materials.

B. Panelboard Nameplates: Engraved laminated plastic or metal nameplate for each panelboard mounted with epoxy or industrial cement or industrial adhesive.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install panelboards and accessory items in accordance with NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less" and manufacturers' written installation instructions.

B. Mounting Heights: Top of trim 6'-2" above finished floor, except as indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount flush panels uniformly flush with wall finish.

D. Circuit Directory: Typed and reflect final circuit changes required to balance panel loads. Obtain approval before installing.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub six 1-inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub six 1-inch empty conduits into raised floor space or below slab other than slabs on grade.

3.2 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs in accordance with Division 16 Section "Electrical Identification."

3.3 GROUNDING

A. Connections: Make equipment grounding connections for panelboards as indicated.
B. Provide ground continuity to main electrical ground bus indicated.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A.

3.5 FIELD QUALITY CONTROL

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests on all mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.
5. Perform visual and mechanical inspection and related work for overcurrent protective devices as specified in Division 16 Section “Overcurrent Protective Devices”.

B. Electrical Tests: Include the following items performed in accordance with manufacturer’s instructions:

1. Ground resistance test on system and equipment ground connections.

C. Re-test: Correct deficiencies identified by tests and observations and provide re-testing of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.

3.6 CLEANING

A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION
SECTION 26 24 19
MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ac motor-control devices rated 600 V and less that are supplied as enclosed units.

B. Related Sections include the following:
   1. Division 26 Section Section "Electrical Identification" for labeling materials.

1.3 SUBMITTALS

A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.

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

C. Maintenance Data: For products to include in the maintenance manuals specified in Division 1.

D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

E. Qualification Data for Field Testing Agency: Certificates, signed by Contractor, certifying that agency complies with requirements specified in "Quality Assurance" Article below.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.

B. Comply with NFPA 70.

C. Listing and Labeling: Provide motor controllers specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

1.5 COORDINATION

A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.
B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Siemens Co.
   4. Square D Co.

2.2 MANUAL MOTOR CONTROLLERS

A. Description: NEMA ICS 2, general purpose, Class A with toggle action and overload element.

2.3 MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

B. Control Circuit: 120 V; obtained from integral control power transformer. Include a control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. Provide red and green pilot lights and H-O-A switch on face of each controller. Include terminal block that is field ready for connection of 2 control contacts and 2 monitoring contacts.

C. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
   1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses indicated. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a Nationally Recognized Testing Laboratory.

D. Overload Relay: NEMA ICS 2, Class 10 tripping characteristics selected to protect motor against voltage unbalance and single phasing.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

PART 3 - EXECUTION

3.1 APPLICATIONS
   A. Select features of each motor controller to coordinate with ratings and characteristics of supply
circuit and motor; required control sequence; duty cycle of motor, drive, and load; and
configuration of pilot device and control circuit affecting controller functions.
   B. Select horsepower rating of controllers to suit motor controlled.
   C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise
indicated.
   D. Use fused combination motor starters for all 3-phase motors above ½ horsepower.
   E. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors
started and stopped by automatic controls or interlocked with other equipment.

3.2 INSTALLATION
   A. Install independently mounted motor-control devices according to manufacturer's written
instructions.
   B. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.
   C. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel
channels bolted to wall. For controllers not at walls, provide freestanding racks.
   D. Install freestanding equipment on concrete housekeeping bases conforming to Section "Cast-in-
Place Concrete."
   E. Motor-Controller Fuses: Install indicated fuses in each fusible switch.

3.3 IDENTIFICATION
   A. Identify motor-control components and control wiring according to Division 26 Section "Electrical
Identification."

3.4 CONTROL WIRING INSTALLATION
   A. Bundle, train, and support wiring in enclosures.
   B. Connect hand-off-automatic switch and other automatic control devices where available.
      1. Connect selector switches to bypass only the manual and automatic control devices that
have no safety functions when switch is in the hand position.
      2. Connect selector switches with motor-control circuit in both hand and automatic positions
for safety-type control devices such as low- and high-pressure cutouts, high-temperature
cutouts, and motor overload protectors.
3.5 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.6 FIELD QUALITY CONTROL

A. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
2. Remove and replace malfunctioning units with new units, and retest.

3.7 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

END OF SECTION
SECTION 26 28 16  
CIRCUIT AND MOTOR DISCONNECTS  

PART 1 - GENERAL  

1.1 RELATED DOCUMENTS  

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

1.2 SUMMARY  

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:  
   1. Service disconnecting means.  
   2. Feeder and branch-circuit protection.  

B. Related Sections include the following:  
   1. Division 26 Section "Switchboards" for individually enclosed, fusible switches used as feeder protection.  

1.3 DEFINITIONS  

A. GFCI:  Ground-fault circuit interrupter.  

B. RMS:  Root mean square.  

C. SPDT:  Single pole, double throw.  

1.4 SUBMITTALS  

A. Product Data:  For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.  

B. Shop Drawings:  For each switch and circuit breaker.  
   1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:  
      a. Enclosure types and details for types other than NEMA 250, Type 1.  
      b. Current and voltage ratings.  
      c. Short-circuit current rating.  
      d. UL listing for series rating of installed devices.  
      e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.  
   3. Dimensioned Outline Drawings of Equipment Unit:  Identify center of gravity and locate and describe mounting and anchorage provisions.
4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

D. Field Test Reports: Submit written test reports and include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

F. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
   1. Routine maintenance requirements for components.
   2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
   3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA AB 1 and NEMA KS 1.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with space provided.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Square D Co.
   3. Siemens Co.

2.2 ENCLOSED SWITCHES

A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 CIRCUIT BREAKERS

A. Enclosed, Molded-Case Circuit Breaker: NEMA AB 1, with lockable handle.

B. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting rating to meet available fault current.

C. Application Listing: Appropriate for application, including switching fluorescent lighting loads or heating, air-conditioning, and refrigerating equipment.

D. Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.


F. Lugs: Compression lugs for all circuit devices 100 Amps and larger.

G. Shunt Trip: Where indicated.

H. Enclosure: NEMA AB 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.
   1. Outdoor Locations: Type 3R.
   3. Other Wet or Damp Indoor Locations: Type 4.

2.4 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Comply with mounting and anchoring requirements specified in other Division 26 Sections.
B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section “Electrical Identification”.
B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS
A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.
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 and UL 486B.

3.5 FIELD QUALITY CONTROL
A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
   2. Test continuity of each line- and load-side circuit.
B. Testing Agency: Owner will engage a qualified independent testing agency to perform specified testing.
C. Testing Agency: Engage a qualified independent testing agency to perform specified testing.
D. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
E. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 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 switches and circuit breakers checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

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

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION
SECTION 26 28 17

OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 26 sections apply to this Section:

1. "Basic Electrical Requirements."

1.2 SUMMARY

A. This Section includes overcurrent protective devices (OCPDs) rated 600 V and below and switching devices commonly used with them.

B. Panelboards, Switchboards, and Motor Control Centers: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 26 sections.

1.3 DEFINITIONS

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

B. Ampere-Squared-Seconds: An expression of available thermal energy resulting from current flow. With regard to current-limiting fuses and circuit breakers, the ampere-squared-seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for fuses, fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.

C. Coordination study performed by a hq professional engineer in accordance with ANSI/IEEE Standard 242-1986, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems." Where OCPD manufacturers other than those designated in schedules of overcurrent protective devices are proposed for use, submit a full coordination study showing graphically that the substitute OCPDs coordinate selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics, device performance curves, and fault current calculations adequate to
demonstrate satisfactory component protection and selective coordination of protective
devices. Study shall be commissioned and paid for by the Contractor.

D. Coordination study performed by a registered professional engineer in accordance with
ANSI/IEEE Standard 242-1986, "Recommended Practice for Protection and Coordination of
Industrial and Commercial Power Systems." Show graphically how overcurrent protective
devices coordinate selectively with both upstream and downstream components. Include
single line diagram, coordinated time-current characteristics, device performance curves, and
fault current calculations adequate to demonstrate satisfactory component protection and
selective coordination of protective devices.

1.5 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70
"National Electrical Code."

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical
Code, Article 100.

C. Single-Source Responsibility: Obtain similar OCPDs from a single manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cartridge Fuses:

   a. Bussmann Div., Cooper Industries, Inc.
   b. Gould Inc.

2. Molded-Case Circuit Breakers:

   b. Cutler-Hammer Co.
   c. General Electric Co.
   d. Square D Co.
   e. Westinghouse Electric Corp.
   f. Siemens Co.

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDS), GENERAL

A. General: Provide OCPDs in indicated types, as integral components of panelboards,
switchboards, and motor control centers; and also as individually enclosed and mounted single
units.

C. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."
2.3 CARTRIDGE FUSES

A. General: NEMA Standard FU1, "Low-Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have voltage ratings consistent with the circuits on which used.

B. Class J Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."

2.4 FUSIBLE SWITCHES


B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.

C. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to faults up to 100,000 RMS symmetrical amperes.

D. Operation: By means of external handle.

E. Interlock: Prevents access to switch interior except when in "off" position.

F. Fuse Clips: Rejection type.

G. Padlocking Provisions: For 2 padlocks, whether open or closed.

H. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. General: UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."

B. Construction: Bolt-in type.

D. Characteristics: Indicated frame size, trip rating, number of poles, and a short-circuit interrupting capacity rating of 10,000 amperes symmetrical, unless a greater rating is indicated.

E. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.

F. Adjustable Instantaneous Trip Devices: Factory adjusted to low-trip-setting current values.

G. Enclosure for Switchboard or Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.

H. Enclosure for Switchboard or Motor Control Center Mounting: Provide individual mounting where indicated.
I. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

J. Combination Circuit Breakers and Ground Fault Circuit Interrupters: UL 943 "Ground Fault Circuit Interrupters," arranged for sensing and tripping for ground fault current in addition to overcurrent and short-circuit current. Provide features as follows:

1. Match features and module size of panelboard breakers and provide clear identification of ground fault trip function.
2. Trip Setting for Ground Fault: 4 to 6 milliamperes, listed and labeled as a class A, type 1 device.
3. Trip Setting for Ground Fault: 30 milliamperes.
4. Trip setting for ground fault as indicated.

K. Circuit Breakers With Solid-State Trip Devices: Provide indicated circuit breakers with solid-state trip devices having the following features:

1. Functions: Long-time-delay, short-time-delay, and instantaneous trip functions, which are independent of each other in both action and adjustment.
2. Temperature compensation to assure accuracy and calibration stability from minus 20 deg C to plus 55 deg C.
3. Field-adjustable, time-current characteristics.
4. Current Adjustability: Effected by operating controls on front panel or by changing plug-in elements or current transformers or sensors.
5. Where indicated, ground fault protection with at least three short-time-delay settings and three trip-time-delay bands. Adjustable current pickup.
6. Trip Indication: Labeled lights or mechanical indicators on trip device shall indicate type of fault causing breaker trip. If lights are used, integral power source shall maintain indication for 60 hours, minimum.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer’s written installation instructions.

B. OCPDs in distribution equipment shall be factory installed.

3.2 IDENTIFICATION

A. Identify components in accordance with Division 26 Section "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between OCPDs and control/indication devices as specified in Division 26 Section "Wires and Cables" for hard wired connections.
3.4 CONNECTIONS

A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment 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.

3.5 GROUNDING

A. Provide equipment grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

3.6 FIELD QUALITY CONTROL

A. Arrange and pay for the services of the manufacturer's electrical testing organization to perform tests and observations on OCPDs.

B. Reports: Prepare written reports certified by testing organization on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made.

C. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

D. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.

E. Visual and mechanical inspection: Include the following inspections and related work.

   1. Overcurrent-Protective-Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.
   2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
   3. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
   4. Check tightness of electrical connections of OCPDs with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
   5. Clean OCPDs using manufacturer's approved methods and materials.
   6. Verify installation of proper fuse types and ratings in fusible OCPDs.

F. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:

   1. Insulation resistance test of OCPD conducting parts. Insulation resistance less than 100 megohms is not acceptable.
   2. Contact resistance test or measurement of millivolt drop across contacts of drawout circuit breakers and fused power circuit devices at rated current. Compare contact
resistance or millivolt drop values of adjacent poles and of similar breakers. Deviations of more than 50 percent are not acceptable.

3. Insulation resistance test of fused power circuit devices and insulated-case and molded-case circuit breakers over 600-ampere frame size at 1000 V d.c. for one minute from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase. Insulation resistance less than 100 megohms is not acceptable.

4. Use primary current injection to check performance characteristics of trip units of insulated-case circuit breakers and molded-case breakers over 600-ampere frame size. Trip characteristics not falling within manufacturer's published time-current characteristic tolerance bands when adjusted to approved parameters are not acceptable. Perform the following tests:

   a. Determine minimum pickup current acceptable per manufacturer's instructions.
   b. Determine long-time delay at 300 percent pickup current.
   c. Determine short-time-pickup current and corresponding delay time.
   d. Determine ground-fault current pickup and corresponding delay time.
   e. Determine instantaneous pickup current value.

5. Verify trip unit reset characteristics for insulated-case circuit breakers.


7. Activate auxiliary protective devices such as ground fault or undervoltage relays, to verify operation of shunt-trip devices.

G. Retest: Correct deficiencies identified by tests and observations and provide retesting of OCPDs by testing organization. Verify by the system tests that specified requirements are met.

3.7 CLEANING

A. Upon completion of installation, inspect OCPDs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 DEMONSTRATION

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPDs and train Owner's maintenance personnel.

B. Conduct a minimum of one half day of training in operation and maintenance as specified under "Instructions to Owner Employees" in the "Project Closeout" Section of these specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.

C. Schedule training with at least seven days’ advance notification.

END OF SECTION
SECTION 26 41 13
LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes lightning protection systems for buildings and associated structures and includes requirements for lightning protection systems components including, but not limited to, the following:

1. Air terminals.
2. Bonding plates.
3. Conductors.
4. Connectors.
5. Fasteners.
7. Grounding rods.
8. Rod clamps.

B. Raceways used for lightning protection system conductors are specified in Division 26 Section "Raceways."

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified, including roof adhesive where used.

C. Shop drawings detailing lightning protection system including, but not limited to, air terminal locations, conductor routing, connections and grounding.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer to install lightning protection system. Refer to Division 1, section "Definitions and Standards" for definition of experienced Installer. Upon request, submit evidence of such qualifications to the Architect.

B. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code."

C. NFPA and UL Compliance: Comply with requirements of NFPA Standard 78, and UL Standard 96 as applicable to lightning protection systems for building projects.

D. LPI Compliance: Comply with requirements of Lightning Protection Institute (LPI) Standards 175, 176, and 177, pertaining to lightning protection system material, components, installation and quality assurance procedures.
E. UL Compliance: Comply with UL Standards 96 and 96A.

F. ANSI Compliance: Comply with applicable requirements of ANSI Standard C2.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection system with the installation of other building systems and components, including electrical wiring, supporting structures and building materials, and metal components requiring interface with lightning protection systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   A-C Lightning Security Inc.
   Bonded Lightning Protection.
   Heary Bros. Lightning Protection.
   Independent Protection Co., Inc.
   Robbins Lightning Protection Co.
   Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Provide lightning protection system materials and components, that comply with manufacturer's standard design, in accordance with published product information. Provide air terminals, bonding plates, conductors, connectors, conductor straps, fasteners, grounding plates, grounding rods, rod clamps, splicers and other components required for a complete system that meets LPI-175, UL 96A or NFPA 78 standards.

B. Type of Metal for air terminals and cables: copper with solid air terminals.

C. Air Terminals for roof mounting: Provide units with bases especially designed for associated roof materials.

D. Ground rods: 5/8-inch minimum diameter by 10-feet long, copper clad steel with minimum 27 percent of the rod weight in the copper cladding.

PART 3 - EXECUTION

3.1 INSTALLATION OF LIGHTNING PROTECTION SYSTEMS

A. Install lightning protection systems as indicated, in accordance with equipment manufacturer's written instructions, and in compliance with applicable installation standards specified above.

B. Install conductors with direct paths from air terminals to ground connections avoiding sharp bends and narrow loops. Where indicated, run conductors in non-metallic raceway, Schedule 40, minimum.

C. Conceal system wiring.
D. Conceal down conductors.

E. Conceal interior wiring.

F. Conceal wiring from normal view from all exterior locations at grade within 200-feet of building.

G. Splices and Clamps: Use approved exothermic welded connections for all conductor splices and all connections between conductors and other components.

H. Air Terminals on Roofing: Use adhesive recommended by manufacturer of air terminals and as approved by manufacturer of roofing material. Comply with manufacturers’ installation instructions.

3.2 CORROSION PROTECTION

A. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture, unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings.

3.3 GROUNDING AND BONDING

A. Provide equipment grounding and bonding connections sufficiently tight to assure permanent and effective grounds and bonds.

3.4 FIELD QUALITY CONTROL

A. Perform inspections of the lightning protection system installation in accordance with LPI-177, "Inspection Guide for LPI Certified Systems." Provide Architect with one copy of LPI-177 and retain one copy at the project site throughout construction for reference.

B. Document the inspections on LPI forms LPI-C1-02 and LPI Form 1-R88. Provide one copy of each completed form to the Architect.

C. Provide advance notice of at least 24 hours to the Architect before concealing lightning protection system work.

D. Provide UL inspection and delivery of UL Master Label "C" to the Architect.

E. Provide LPI Certification of the system, obtaining necessary certifications and signatures and preparing and handling necessary forms.

END OF SECTION
SECTION 26 43 13
SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS
A. Nominal: Nominal discharge current.
B. MCOV: Maximum continuous operating voltage.
C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
E. OCPD: Overcurrent protective device.
F. SCCR: Short-circuit current rating.
G. SPD: Surge protective device.
H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Nominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
   3. Complete with all technical information, unit dimensions, detailed installation instructions, maintenance manual, recommended replacement parts list and wiring configuration.
4. Manufacturer’s catalog data, technical information and specifications on equipment proposed for use.
5. Documentation stating that the Surge Protection Device is listed by UL to UL1449 3rd Edition, category code VZCA.
6. Actual let-through voltage data in the form of oscillograph results for both ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (Ring wave) tested in accordance with ANSI/IEEE C6245.
7. Noise Rejection testing as outlined in NEMA LS1-1992 (R2000) Section 3.11. Noise rejection is to be measured between 50kHz and 100MHz verifying the devices noise attenuation. Show multiple attenuation levels over a range of frequencies.
8. Test reports from a recognized independent testing laboratory, capable of producing 200kA surge current waveforms, verifying the suppressor components can survive published surge current rating on a per mode basis using the ANSI/IEEE C62.41 impulse waveform C3 (8 x 20 microsecond, 20kV/10kA). Test data on an individual module is not acceptable.
9. Warranty statement clearly establishing the terms and conditions to the building/facility owner/operator.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.
B. Sample Warranty: For manufacturer's special warranty.

1.6 QUALITY ASSURANCE

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Comply with NFPA 70.
C. Service entrance type surge protection devices suitable for use as Type 1 or Type 2 devices per UL1449 3rd Edition, applied to the line or load side of the utility feed inside the facility.
D. MCOV of the SPD shall be the nominal system voltage.
E. UL 1283.
H. UL96A
I. IEEE 1100 Emerald Book.
1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8 WARRANTY

A. Manufacturer’s Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE SUPPRESSOR

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

1. Current Technologies or Engineer-approved equal.

B. For approved equivalent. 2 weeks prior to bid, submit package to engineer date demonstrating compliance with all performance characteristics included in this specification, paragraph-by-paragraph.

C. Refer to drawings for operating voltage.

D. Declared Maximum Continuous Operating Voltage (MCOV) shall above 115 percent of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL1449 3rd Edition, section 37.7.3. MCOV values claimed based on the component’s value or on the 30-minute 115% operational voltage test, section 38 in UL1449 are not be acceptable.

E. When exposed to a minimum of 14,000 repeated category C3 (20kV/10kA) surges, less than 10% deterioration or degradation of the UL1449 3rd Edition Voltage Protection Rating (VPR). Provide a test report validating the repetitive surge tests performed.

F. Protection Modes UL1449 3rd Edition VPR(6kV, 3kA) for grounded WYE/delta and High Leg Delta circuits with voltages of (480Y/277), (208Y/120), (600Y/347). 3-Phase, 4 wire circuits, (120/240) split phase shall be as follows and comply with test procedures outlined in UL1449 3rd Edition section 37.6:

<table>
<thead>
<tr>
<th>System</th>
<th>Mode</th>
<th>MCOV</th>
<th>B3 Ringwave 6kV, 500A</th>
<th>C3 Comb. Wave 20kV, 10kA</th>
<th>UL 1449 Third Edition VPR Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/240, 208Y/120V</td>
<td>L-N</td>
<td>150</td>
<td>490</td>
<td>980</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>L-G</td>
<td>150</td>
<td>570</td>
<td>980</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>N-G</td>
<td>150</td>
<td>640</td>
<td>1170</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>L-L</td>
<td>300</td>
<td>500</td>
<td>1600</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>L-N</td>
<td>320</td>
<td>450</td>
<td>1420</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>L-G</td>
<td>320</td>
<td>540</td>
<td>1540</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>N-G</td>
<td>320</td>
<td>570</td>
<td>1600</td>
<td>1000</td>
</tr>
<tr>
<td>480Y/277V</td>
<td>L-L</td>
<td>552</td>
<td>530</td>
<td>2600</td>
<td>2000</td>
</tr>
</tbody>
</table>
G. Electrical Noise Filter- high performance EMI/RFI noise rejection filter with a maximum attenuation of 54dB per MIL-STD-220B. Include a EMI/RFI noise rejection filter for all L-N modes as well as a removable filter in the N-G mode.

H. Capable of preventing common temporary overvoltages and high impedance faults from damaging MOVs, increasing their longevity and ability to protect the critical load. Limited and Intermediate current TOVs (as specified in UL 1449 article 39.3 and 39.4) caused by a loss of the neutral conductor in a split phase or three phase power system. Available fault current determined by the impedance of the loads connected to the phases opposite the SPD and typically in the range of 30A to 1000A.

I. Selenium elements must limit voltage to the MOV as a percent of nominal as outlined below:

<table>
<thead>
<tr>
<th>time</th>
<th>30A</th>
<th>100A</th>
<th>500A</th>
<th>1000A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cycle</td>
<td>120%</td>
<td>130%</td>
<td>150%</td>
<td>160%</td>
</tr>
<tr>
<td>10 cycles</td>
<td>130%</td>
<td>150%</td>
<td>160%</td>
<td>160%</td>
</tr>
<tr>
<td>30 cycles</td>
<td>140%</td>
<td>150%</td>
<td>160%</td>
<td>160%</td>
</tr>
</tbody>
</table>

*To verify damage to the MOVs has been mitigated, the percent overvoltage seen at the MOV must be less than 200% for split-phase applications or 173% for three-phase applications (100% is nominal).

J. Withstand multiple TOVs without damage to the MOVs by shunting current away from the MOVs during the overvoltage. Ability to withstand >100 TOVs with a source current of 30A, duration of 30 cycles, with 10s between TOV events.

K. For service entrance protector, incorporate a combination of TPMOV and Selenium technology allowing for transient surge and temporary over voltage protection.

L. Integral Disconnect Switch.

M. NEMA compliant safety interlocked integral disconnect switch with an externally mounted metal manual operator, capable of disconnecting all ungrounded circuit conductors from the distribution system to enable testing and maintenance without interruption to the facility's distribution system. Rated for 600Vac.

N. Tested to UL1449 3rd Edition listed with the integral disconnect switch and the UL1449 VPR ratings shall be provided.

O. Integral disconnect switch shall be capable of withstanding, without failure, the published maximum surge current magnitude without failure or damage to the switch.

P. Line side of the integral disconnect shall be barriered so that when the SPD is opened, no direct access to the voltage is possible.

Q. UL1449 Voltage Protective Rating (VPR) shall be permanently affixed.

R. UL1449 Nominal Discharge Surge Current Rating shall be 20kA.

S. SCCR rating of 200kAIC without the need for upstream over current protection.

T. Listed as Type1 SPD, suitable for use in Type1 or Type2 applications.
U. Provide following monitoring options.
   1. Time Date stamp, duration and magnitude for the following power quality events (sags, swells, surges, dropouts, outages, THD, frequency, Volts RMS per phase)
   2. Track surge protection and display it as a percentage of remaining protection.
   3. Surge counter with three categories to be defined as:
      a. Low Level surge (100A-500A).
      b. Medium Level surge (500A-3,000A).
      c. High Level surge (>3,000A)
   4. Remote communications via ModBus or Ethernet
   5. Form-C contacts rated at 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status.

2.2 ENCLOSURES
   A. Indoor Enclosures: NEMA 250, Type 1.

2.3 CONDUCTORS AND CABLES
   A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
   B. If installed lead length exceeds 5'6", use low impedance (HPI) cable.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Comply with NECA 1.
   B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
   C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
   D. Use crimped connectors and splices only. Wire nuts are unacceptable.
   E. Wiring:
      1. Power Wiring: Comply with wiring methods in Section 260519 "Wires and Cables."
      2. Controls: Comply with wiring methods in Section 260519 "Wires and Cables."

3.2 FIELD QUALITY CONTROL
   A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 43 13
PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section includes the following types of LED luminaires:
      2. Downlight.
      3. Highbay, linear.
      4. Recessed linear.
      5. Strip light.
      7. Surface mount, nonlinear.
      8. Suspended, linear.
      9. Suspended, nonlinear.
     11. Finishes.
     12. Luminaire support.

   B. Related Requirements:
      1. Section 260943 "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.3 DEFINITIONS
   A. CCT: Correlated color temperature.
   B. CRI: Color Rendering Index.
   C. Fixture: See "Luminaire."
   D. IP: International Protection or Ingress Protection Rating.
   E. LED: Light-emitting diode.
   F. Lumen: Measured output of lamp and luminaire, or both.
   G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.
1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
   6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
      a. Manufacturers’ Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Luminaires.
   2. Suspended ceiling components.
   3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
   4. Structural members to which equipment or luminaires will be attached.
   5. Initial access modules for acoustical tile, including size and locations.
   6. Items penetrating finished ceiling, including the following:
      a. Other luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Smoke and fire detectors.
      f. Occupancy sensors.
      g. Access panels.
      h. Ceiling-mounted projectors.
   7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.
C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers’ codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
   1. Obtain Architect's approval of luminaires in mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
1.9 DELIVERY, STORAGE, AND HANDLING
A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY
A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 LUMINAIRE REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Standards:
   1. ENERGY STAR certified.
   2. UL Listing: Listed for damp location.
   3. Recessed luminaires shall comply with NEMA LE 4.
   4. User Replaceable Lamps:
      a. Bulb shape complying with ANSI C78.79.
      b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
C. CRI of minimum 80.
D. Rated lamp life of 50,000 hours to L70.
E. Lamps dimmable from 100 percent to 0 percent of maximum light output.
F. Internal driver.
G. Nominal Operating Voltage: 120 V ac or 277 V ac.
   1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
H. Housings:
   1. Extruded-aluminum housing and heat sink.
   2. Clear anodized powder-coat painted finish.
2.3 CYLINDER
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. With integral mounting provisions.

2.4 DOWNLIGHT
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. Universal mounting bracket.
C. Integral junction box with conduit fittings.

2.5 HIGHBAY, LINEAR
A. Subject to compliance with requirements, provide product indicated on Drawings.

2.6 RECESSED LINEAR
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. Integral junction box with conduit fittings.

2.7 STRIP LIGHT
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. Integral junction box with conduit fittings.

2.8 SURFACE MOUNT, LINEAR
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. Integral junction box with conduit fittings.

2.9 SURFACE MOUNT, NONLINEAR
A. Subject to compliance with requirements, provide product indicated on Drawings.
B. Integral junction box with conduit fittings.

2.10 SUSPENDED, LINEAR
A. Subject to compliance with requirements, provide product indicated on Drawings.
2.11 SUSPENDED, NONLINEAR

A. Subject to compliance with requirements, provide product indicated on Drawings.

B. Integral junction box with conduit fittings.

2.12 LED EMERGENCY LIGHTING FIXTURES

A. Internal Type: Self-contained, modular, LED emergency driver battery-inverter unit factory mounted within fixture body. Comply with UL 924.
   1. Emergency Connection (Switched Fixture): Connect unswitched circuit to LED emergency driver battery-inverter unit and switched circuit to normal driver.
   2. Night Light Connection: Connect unswitched circuit to both LED emergency driver battery-inverter unit and normal driver.
   3. Test Switch and Light-Emitting-Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   4. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
   5. Charger: Fully automatic, solid-state, constant-current type.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more LED light fixtures, remote mounted from light fixture. Comply with UL 924.
   1. Emergency Connection (Switched Fixture): Connect unswitched circuit to LED emergency driver battery-inverter unit and switched circuit to normal driver.
   2. Night Light Connection: Connect unswitched circuit to both LED emergency driver battery-inverter unit and normal driver.
   3. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
   5. Housing: NEMA 250, Class 1 enclosure.

2.13 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
   1. Tempered Fresnel glass, prismatic glass, diffuse glass, clear glass, prismatic acrylic, or clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized powder-coat painted finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI for all luminaires.

2.14 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.15 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
I. Ceiling-Grid-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
   1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
   2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
   3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 51 19
SECTION 26 56 19
LED EXTERIOR LIGHTING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire supports.
   3. Luminaire-mounted photoelectric relays.
B. Related Requirements:
   1. Section 260943 "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.3 DEFINITIONS
A. CCT: Correlated color temperature.
B. CRI: Color rendering index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of luminaire.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The
adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which equipment and luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source quality-control reports.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.
1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

E. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

### 1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   
   a. Structural failures, including luminaire support components.
   b. Faulty operation of luminaires and accessories.
   c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 5 year(s) from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

#### 2.2 LUMINAIRE REQUIREMENTS

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

B. UL Compliance: Comply with UL 1598 and listed for wet location.

C. Lamp base complying with ANSI C81.61 or IEC 60061-1.

D. Bulb shape complying with ANSI C79.1.

E. CRI of minimum 80. CCT of 3500 K.

F. L70 lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. Nominal Operating Voltage: 120 V ac or 277 V ac.

J. In-line Fusing: On the primary for each luminaire.

K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.
L. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:
   1. Subject to compliance with requirements, provide product indicated on Drawings.
   2. Luminaire-Mounting Height: Coordinate with Architect.
   4. Housings:
      a. Extruded-aluminum housing and heat sink.
      b. Clear anodized powder-coat painted finish.
      c. 

B. Canopy:
   1. Subject to compliance with requirements, provide product indicated on Drawings.
   3. Housings:
      a. Extruded-aluminum housing and heat sink.
      b. Clear anodized powder-coat painted finish.

2.4 LED EMERGENCY LIGHTING FIXTURES

A. Internal Type: Self-contained, modular, LED emergency driver battery-inverter unit factory mounted within fixture body. Comply with UL 924.
   1. Emergency Connection: Connect unswitched circuit to LED emergency driver battery-inverter unit and switched circuit to normal driver.
   2. Test Switch and Light-Emitting-Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   3. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more LED light fixtures, remote mounted from light fixture. Comply with UL 924.
   1. Emergency Connection: Connect unswitched circuit to LED emergency driver battery-inverter unit and switched circuit to normal driver.
   2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
   4. Housing: NEMA 250, Class 1 enclosure.
2.5 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum or Stainless steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:
   1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   2. Glass: Annealed crystal glass unless otherwise indicated.
   3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

G. Housings:
   1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
   2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. "USE ONLY" and include specific lamp type.
      b. Lamp diameter, shape, size, wattage and coating.
      c. CCT and CRI for all luminaires.

2.6 FINISHES

A. 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.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
   a. Color: As specified on plans or in submittal review.

C. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: As specified on plans or in submittal review.

2.7 LUMINAIRE SUPPORT COMPONENTS
A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
C. Examine walls, roofs, canopy ceilings, and overhang ceilings for suitable conditions where luminaires will be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 TEMPORARY LIGHTING
A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS
A. Comply with NECA 1.
B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
C. Install lamps in each luminaire.
D. Fasten luminaire to structural support.
E. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Support luminaires without causing deflection of finished surface.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls.
H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.
I. Coordinate layout and installation of luminaires with other construction.
J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES
A. Aim as indicated on Drawings.
B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."
3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following applicable IES testing guide(s):

   a. IES LM-5.
   b. IES LM-50.
   c. IES LM-52.
   d. IES LM-64.
   e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.
3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 56 19
SECTION 27 41 13
ARCHITECTURALLY INTEGRATED AUDIOVISUAL INFRASTRUCTURE

PART 1 GENERAL

1.1 CONDITIONS AND REQUIREMENTS

A. The General Conditions, Supplementary Conditions, and Division 01 – General Requirements apply.

1.2 SECTION INCLUDES

A. Floor Boxes
B. Poke-Thru Devices
C. Flat Panel Display In-Wall Storage Boxes
D. Wall Junction Boxes
E. Pull Boxes
F. Plenum Ceiling Boxes
G. Projection Screens

1.3 RELATED SECTIONS

A. Division 09 – Flooring Systems
B. Division 26 – Electrical: Electrical Systems and Components
C. Division 27 – Communications: Communications Systems and Components
D. Division 28 – Electronic Safety and Security: Security Systems and Components

1.4 Submittals

A. Comply with requirements of Section 01 33 00 – Submittal Procedures.

1.  Product Data: For the following AV Infrastructure System components:

   a. Floor Boxes
   b. Poke-Thru Devices
   c. Flat Panel Display In-Wall Storage Boxes
   d. Wall Junction Boxes
   e. Pull Boxes
   f. Plenum Ceiling Boxes
   g. Projection Screens

2. Shop Drawings: For the following AV Infrastructure System components. Include plans, elevations, sections, details, and attachments to other work:

   a. Floor Boxes
   b. Poke-Thru Devices
   c. Flat Panel Display In-Wall Storage Boxes
   d. Wall Junction Boxes
   e. Pull Boxes
   f. Plenum Ceiling Boxes
   g. Projection Screens
1.5 QUALITY ASSURANCE

A. General:

1. Floor Boxes provide the interface between power, audio-video (A/V), and communications cabling in concrete floors and decks at activation locations requiring power, audio-video, or communication device outlets.
   a. ADA Compliance: Flush-mounted floor device outlets shall not create tripping hazard.

2. Poke-thru devices provide the interface between power, communication and audio-video (A/V) cabling in an above grade concrete floor and the activation location where power communication and/or A/V device outlets are required. These poke-thru devices provide recessed device outlets that will not obstruct the floor area.
   a. ADA Compliance: Flush-mounted floor device outlets shall not create tripping hazard.

3. Flat Panel Display In-Wall Storage Boxes provide the interface between power, audio-video (A/V), and communications cabling in recessed cavity of wall behind flat panel displays where power, communication and/or A/V device outlets and/or device storage/mounting is required.

4. Wall Outlet Boxes provide the interface between power, audio-video (A/V) and communications cabling in walls at activation locations requiring power, audio-video, or communication device outlets.

5. Pull and Junction boxes provide an accessible pathway in a run of conduit to facilitate the pulling in of wires and cables.

B. Manufacturer Qualifications: Firms regularly engaged in manufacture of floor boxes, poke-thru devices and in-wall storage boxes of the types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years. Provide floor boxes, poke-thru devices, in-wall storage boxes, electrical junction boxes, pull boxes and plenum ceiling boxes that are produced by a manufacturer listed in this section.

C. Electrical Raceways and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to raceways and components. Listed and labeled in accordance with NFPA 70, Article 100.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver floor boxes, poke-thru devices, and in-wall storage boxes and associated fittings in factory labeled packages.

B. Store and handle in strict compliance with manufacturer’s written instructions and recommendations.

C. Protect from damage due to weather, excessive temperature, and construction operations.

PART 2 PRODUCTS

2.1 GUIDELINES

A. Floor Boxes, Poke-thru Devices, Wall Junction Boxes and Pull & Junction Boxes shall be furnished and installed by the Electrical Contractor selected by the Owner unless specifically excluded in these specifications or drawings.
1. Coordinate with AV Contractor regarding proper placement of duplex outlets for any AV designated floor box or Poke-thru Device. Electrical circuits should be connected (and outlets wired) to the designated AV circuit breaker panel (N.I.C.). Ensure that “Star” ground configuration is properly implemented. Ensure that ground wires from each outlet are isolated from conduit, neutrals, and each other.

B. In-Wall Storage Boxes and Plenum Ceiling Boxes shall be furnished, and installed by the Electrical Contractor unless specifically excluded in these specifications or drawings.

1. Coordinate with AV Contractor regarding proper placement of duplex outlets for any AV designated Plenum Ceiling Box and/or In-Wall Storage Box.

C. Floor Box Inserts/Plate and Poke-thru Device Inserts/Plates shall be furnished and installed by the AV Contractor selected by the Owner unless specifically excluded in these specifications or drawings.

D. Condition - Provide and install products listed in this section in factory new condition, conforming to applicable provisions of American National Standards Institute.

2.2 ACCEPTABLE MANUFACTURER

A. Basis of Design Product:


3. The design for in-wall storage boxes and fittings is based on the PAC52* Series In-Wall Storage Box Series manufactured by Chief Manufacturing, 6436 City West Parkway, Eden Prairie, MN 55344, toll-free 800-582-6480, telephone 952-894-6280, fax 877-894-6918, Web Site: www.chiefmfg.com.

4. The design for wall junction boxes and fittings is based on products manufactured by RACO, 3902 West Sample Street, South Bend IN 46634-4002, telephone 800-722-6437, Web Site: www.hubbell-rtb.com. (OR: Garvin Industries, 3700 Sandra Street, Franklin Park, IL, telephone 847-455-0188, fax 847-455-0334; Web Site: www.garvinindustries.com).


7. The design for projection screens is based on products manufactured by Draper, Inc., 411...
2.3 FLOOR BOXES

A. Classification and Use: Floor boxes shall have been examined and tested by Underwriters Laboratories Inc. to meet UL514A and/or UL514C and Canadian Standard C22.2, No. 18.1-04 and 18.2-06 and bear the U.S. and Canadian UL Listing Mark. Floor boxes shall also have been tested by Underwriters Laboratories Inc. and classified for fire resistance and bear the U.S. and Canadian UL Classification Mark. Devices shall be classified for use in 2-hour rated, unprotected reinforced concrete floors and 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series Designs) or concrete floors with suspended ceilings (fire resistive designs with suspended ceilings should have provisions for accessibility in the ceiling below the floor boxes). Floor boxes shall also conform to the standards set in Section 300-21 of the National Electrical Code. Floor boxes shall meet UL scrub water requirements, but are not suitable for wet or damp locations, or other areas subject to saturation with water or other liquids such as commercial kitchens. Floor boxes shall also have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, bare concrete, terrazzo, wood, and carpet covered floors. Floor boxes shall be suitable for use in air handling spaces in accordance with Section 300-22 (C) of the National Electrical Code.

B. Floor Boxes, General: Evolution Series Floor Boxes for use on above grade concrete floors, raised floors or wood floors. Provide boxes with a component to permit installation in polished concrete or terrazzo floors. Boxes shall be compatible with complete line of Ortronics® workstation connectivity outlets and modular inserts.

1. Floor boxes provide the interface between power, communication and audio/video (A/V) cabling in above-grade floors, on-grade concrete floors, raised floors, wood floors, and fire-classified floors and the workstation or activation location where power and communication and/or A/V device outlets are required. Boxes shall provide recessed device outlets that will not obstruct the floor area. Refer to Drawings for size and types.

2. Floor boxes shall permit all wiring to be completed at floor level. The FC models shall be used as defined by the UL Fire Resistance Directory at a minimum spacing of two (2) ft. [610mm] on center.

C. (FB TYPE 1) Model EFB6S Floor Boxes: Manufactured from stamped steel approved for use on above grade concrete floors, raised floors and wood floors with the same product. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16" L x 13-7/8" W x 4-3/16" H [385mm x 351mm x 107mm]. Provide boxes with provisions that enable installation into concrete floors, raised floors, or wood floors without having to purchase additional components or accessories. Provide boxes with six (6) independent wiring compartments that allow for up to six (6) receptacles, communication and/or audio/video services. Boxes shall have removable and relocatable dividers to permit custom configuration of compartments as well as permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the four (4) outer compartments shall have a minimum wiring capacity of 32-in³ [524ml]. Each of the two (2) center compartments shall have a minimum wiring capacity of 38.5-in³ [630ml]. Each of the six (6) compartments shall have a minimum depth of 3-7/8" [98mm] behind the plate. Provide boxes with removable compartments to...
facilitate installation and moves, additions, and changes. The compartments shall be removable from the top and back of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable knockout plates to allow for the maximum cable pass-through area. The cable pass-through area shall be a minimum of 6-15/16 in² [176mm²]. The box shall contain the following number of knockouts: 10 1" trade size, six (6) 1-1/4" trade size, six (6) 3/4" trade size, and two (2) 2" trade size. Boxes shall be able to accept up to (6) six 2" trade size conduit feeds in the sides of the boxes, through the use of the EFB6S-2HUB and maintain a 4-inch deep concrete pour. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. Equip boxes with toggle clamps to allow box to be secured to raised and wood floors. The box shall be able to accept 2-3/4" x 4-1/2" standard size wall plates. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles, Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

D. (FB TYPE 2) Model EFB6S-OG Floor Boxes: Manufactured from stamped steel approved for use in above grade and on-grade floor applications. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall be painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and be approved for use on-grade and above grade floors. Boxes shall be 15-3/16" L x 13-7/8" W x 4-3/16" H [385mm x 351mm x 107mm]. Provide boxes with six (6) independent wiring compartments that allow for up to six (6) duplex receptacles, communication and/or audio/video services. Boxes shall have removable and relocatable dividers to permit custom configuration of compartments as well as permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the four (4) outer compartments shall have a minimum wiring capacity of 32-in³ [524ml]. Each of the two (2) center compartments shall have a minimum wiring capacity of 38.5-in³ [630ml]. Each of the six (6) compartments shall have a minimum depth of 3-7/8" [98mm] behind the plate. Provide boxes with removable compartments to facilitate installation. The compartments shall be removable from the top of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. The box shall contain the following number of knockouts: 10 1" trade size, six (6) 1-1/4" trade size, six (6) 3/4" trade size, and two (2) 2" trade size. Boxes shall be able to accept up to (6) six 2" trade size conduit feeds in the sides of the boxes, through the use of the EFB6S-2HUB and maintain a 4-inch deep concrete pour. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. The box shall be able to accept 2-3/4" x 4-1/2" standard size wall plates. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles, Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

E. (FB TYPE 3) Model EFB6S-FC Floor Boxes: Manufactured from stamped steel approved for use in 2-hour fire-rated concrete floors. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16" L x 13-7/8" W x 4-3/16" H [385mm x 351mm x 107mm]. Provide boxes with a 21-3/4" L x 17-1/4" W x 6-1/2" H [552mm x 438mm x 165mm] sheet metal concrete pan to ensure that 3-1/4 inches [83mm] of concrete surrounds the box. Provide boxes with six (6) independent wiring compartments that allow for up to six (6) receptacles, communication and/or audio/video services. Boxes shall permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the four (4) outer compartments shall have a minimum wiring capacity of 32-in³ [524ml]. Each of the two (2) center compartments shall have a minimum wiring capacity of 38.5-in³ [630ml]. Each of the six (6) compartments shall have a minimum depth of 3-7/8" [98mm] behind the plate. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box.
Provide boxes with four (4) intumescent services feed stems with a 1-1/4-inch [32mm] pass-through channel that allows the pathway to close off during a fire. Boxes shall be fully adjustable, accommodating a maximum 2-1/2-inch [64mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. The box shall be able to accept 2-3/4" x 4-1/2" standard size wall plates. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles, Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

F. (FB TYPE 4) Model EFB8S Floor Boxes: Manufactured from stamped steel approved for use on above grade concrete floors, raised floors and wood floors with the same product. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based back painted enamel finished interior (white). Boxes shall be 15-3/16" L x 12-3/4" W x 6-1/16" H [385mm x 324mm x 154mm]. Provide boxes with provisions that enable installation into concrete floors, raised floors or wood floors without having to purchase additional components or accessories. Provide boxes with eight (8) independent wiring compartments that allow for up to eight (8) receptacles, communication and/or audio/video services. Boxes shall accept standard size single gang (2-3/4" x 4-1/2"), double gang (4-9/16" x 4-1/2"), and triple gang (6-3/8" x 4-1/2") wall plates. Boxes shall permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the four (4) outer compartments shall have a minimum wiring capacity of 28-in³ [455ml]. Each of the four (4) center compartments shall have a minimum wiring capacity of 34-in³ [524ml]. Each of the eight (8) compartments shall have a minimum depth of 3-1/2" [89mm] behind the plate. Provide boxes with removable compartments to facilitate installation and moves, additions, and changes. The compartments shall be removable from the top and back of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable knockout plates to allow for the maximum cable pass-through area. The cable pass-through area shall be a minimum of 11-5/8 in² [7500mm²]. The box shall contain the following number of knockouts: four (4) 3/4-inch trade size, eight (8) 1-inch trade size, six (6) 1-1/4-inch trade size, and two (2) 2-inch trade size. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. Equip boxes with toggle clamps to allow box to be secured to raised and wood floors. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

G. (FB TYPE 5) Model EFB8S-OG Floor Boxes: Manufactured from stamped steel approved for use in above grade and on-grade floor applications. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall be painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and be approved for use on-grade and above grade floors. Boxes shall be 15-3/16" L x 12-5/8" W x 6-1/16" H [385mm x 321mm x 154mm]. Provide boxes with eight (8) independent wiring compartments that allow for up to eight (8) duplex receptacles, communication and/or audio/video services. Boxes shall have removable and relocatable dividers to permit custom configuration of compartments as well as permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the four (4) outer compartments shall have a minimum wiring capacity of 28-in³ [455ml]. Each of the four (4) center compartments shall have a minimum wiring capacity of 34-in³ [524ml]. Each of the eight (8) compartments shall have a minimum depth of 3-1/2" [89mm] behind the plate. Provide boxes with removable compartments to facilitate installation. The compartments shall be removable from the top of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. The box shall contain the following number of...
I. (FB TYPE 6) Model EFB8S-FC Floor Boxes: Manufactured from stamped steel approved for use in 2-hour fire-rated concrete floors. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16" L x 13-7/8" W x 4-3/16" H [385mm x 351mm x 107mm]. Provide boxes with a 21-3/4" L x 17-1/4" W x 6-1/2" H [552mm x 438mm x 165mm] sheet metal concrete pan to ensure that 3-1/4 inches [83mm] of concrete surrounds the box. Provide boxes with eight (8) independent wiring compartments that allow for up to eight (8) receptacles, communication and/or audio/video services. Boxes shall have removable and repositionable dividers to permit feed to adjacent compartments and reconfiguration of devices. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the compartments shall have a minimum wiring capacity of 53-in³ [860ml]. Each of the eight (8) compartments shall have a minimum depth of 3-1/2" [89mm] behind the plate. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable compartments to facilitate installation. Provide boxes with four (4) intumescent services feed stems with a 1-1/4-inch [32mm] pass-through channel that allows the pathway to close off during a fire. Boxes shall be fully adjustable, accommodating a maximum 2-1/2-inch [64mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. The box shall be able to accept standard size single gang (2-3/4" x 4-1/2"), double gang (2-3/4" x 4-1/2"), and triple gang (6-3/8" x 4-1/2") wall plates. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

H. (FB TYPE 6) Model EFB8S-FC Floor Boxes: Manufactured from stamped steel approved for use in 2-hour fire-rated concrete floors. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16" L x 13-7/8" W x 4-3/16" H [385mm x 351mm x 107mm]. Provide boxes with a 21-3/4" L x 17-1/4" W x 6-1/2" H [552mm x 438mm x 165mm] sheet metal concrete pan to ensure that 3-1/4 inches [83mm] of concrete surrounds the box. Provide boxes with eight (8) independent wiring compartments that allow for up to eight (8) receptacles, communication and/or audio/video services. Boxes shall have removable and repositionable dividers to permit feed to adjacent compartments and reconfiguration of devices. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the compartments shall have a minimum wiring capacity of 53-in³ [860ml]. Each of the eight (8) compartments shall have a minimum depth of 3-1/2" [89mm] behind the plate. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable compartments to facilitate installation. Provide boxes with four (4) intumescent services feed stems with a 1-1/4-inch [32mm] pass-through channel that allows the pathway to close off during a fire. Boxes shall be fully adjustable, accommodating a maximum 2-1/2-inch [64mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. The box shall be able to accept standard size single gang (2-3/4" x 4-1/2"), double gang (2-3/4" x 4-1/2"), and triple gang (6-3/8" x 4-1/2") wall plates. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

I. (FB TYPE 7) Model EFB10S Floor Boxes: Manufactured from stamped steel approved for use on above grade concrete floors, raised floors and wood floors with the same product. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16" L x 12-3/4" W x 6-1/16" H [385mm x 324mm x 154mm]. Provide boxes with provisions that enable installation into concrete floors, raised floors, or wood floors without having to purchase additional components or accessories. Provide boxes with 10 independent wiring compartments that allow for up to 10 receptacles, communication and/or audio/video services. Boxes shall permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Six (6) of the 10 compartments shall have a minimum wiring capacity of 23-1/2-inch³ [597ml]. Four (4) of the 10 compartments shall have a minimum wiring capacity of 27-inch³ [686ml]. Each of the 10 compartments shall have a minimum depth of 3-1/2" [89mm] behind the plate. Provide boxes with removable compartments to facilitate installation and moves, additions, and changes. The compartments shall be removable from the top and back of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable knockout plates to allow for the maximum cable pass-through area. The cable pass-through area shall be a minimum of 11-5/8 in² [7500mm²]. The box shall contain the following number of knockouts: four (4) 3/4-inch trade size, 10 1-inch trade size, eight (8) 1-1/4-inch trade size, and two (2) 2-inch trade size. Boxes shall be fully adjustable, accommodating a
maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. Equip boxes with toggle clamps to allow box to be secured to raised and wood floors. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

J. (FB TYPE 8) Model EFB10S-OG Floor Boxes: Manufactured from stamped steel approved for use in above grade and on-grade floor applications. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall be painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and be approved for use on-grade and above grade floors. Boxes shall be 15-3/16” L x 12-5/8” W x 6-1/16” H [385mm x 321mm x 154mm]. Provide boxes with 10 independent wiring compartments that allow for up to 10 duplex receptacles, communication and/or audio/video services. Boxes shall have removable and relocatable dividers to permit custom configuration of compartments as well as permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Six (6) of the 10 compartments shall have a minimum wiring capacity of 23-1/2-in³ [597ml]. Four (4) of the 10 compartments shall have a minimum wiring capacity of 27-in³ [686ml]. Each of the 10 compartments shall have a minimum depth of 3-1/2” [89mm] behind the plate. Provide boxes with removable compartments to facilitate installation. The compartments shall be removable from the top of the floor box. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. The box shall contain the following number of knockouts: 14 1-inch trade size, six (6) 1-1/4-inch trade size, and four (4) 2-inch trade size. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2” [12.7mm] post-concrete pour adjustment. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

K. (FB TYPE 9) Model EFB10FC Floor Boxes: Manufactured from stamped steel approved for use in 2-hour fire-rated concrete floors. Boxes shall have the ability to accept a component (EFB610-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall have a polyester based backed enamel finished interior (white). Boxes shall be 15-3/16” L x 13-7/8” W x 4-3/16” H [385mm x 351mm x 107mm]. Provide boxes with a 21-3/4” L x 17-1/4” W x 6-1/2” H [552mm x 438mm x 165mm] sheet metal concrete pan to ensure that 3-1/4 inches [83mm] of concrete surrounds the box. Provide boxes with 10 independent wiring compartments that allow for up to 10 receptacles, communication and/or audio/video services. Boxes shall have removable and repositionable dividers to permit feed to adjacent compartments and reconfiguration of devices. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. Each of the compartments shall have a minimum wiring capacity of 53-in³ [860ml]. Each of the 10 compartments shall have a minimum depth of 3-1/2” [89mm] behind the plate. Provide boxes with two (2) cable guides to organize and maintain the cables egress out of the box. Provide boxes with removable compartments to facilitate installation. The compartments shall be removable from the top of the floor box. Provide boxes with four (4) intumescent services feed stems with a 1-1/4-inch [32mm] pass-through channel that allows the pathway to close off during a fire. Boxes shall be fully adjustable, accommodating a maximum 2-1/2-inch [64mm] pre-concrete pour and a maximum 1/2” [12.7mm] post-concrete pour adjustment. Include mounting brackets with the boxes that will accommodate 15 amp, 20 amp straight blade, 20 amp turn lock, 30 amp straight blade and 30 amp turn lock receptacles. Boxes shall have the ability to accommodate a bracket (EFB-50A) allowing for one (1) 50-amp receptacle. Boxes shall also accommodate Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.
manufacturers, and other open system devices.

L. (FB TYPE 10) Model EFBFF Floor Boxes: Manufactured from stamped steel approved for use on above grade concrete floors, raised floors and wood floors with the same product. Boxes shall have the ability to accept a component (FP-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall be 7-1/16" L x 6-5/8" W x 4-1/8" H [179mm x 168mm x 105mm]. Provide boxes with provisions that enable installation into concrete floors, raised floors, or wood floors without having to purchase additional components or accessories. Provide boxes with two (2) independent wiring compartments that allow for power, communication and/or audio/video services. Each of the two (2) wiring compartments shall have a minimum wiring capacity of 64-1/2-in³ [1056ml]. The box shall be equipped with a metal divider to separate the services and maintain code requirements. The box shall contain the following number of knockouts: four (4) 1/2-inch trade size, four (4) 3/4"-inch trade size, one (1) 1-inch trade size, six (6) 1-1/4-inch trade size, one (1) 1-1/2-inch trade size, and two (2) 2-inch. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment. Equip boxes with toggle clamps to allow box to be secured to raised and wood floors.

M. (FB TYPE 11) Model EFBFF-OG Floor Boxes: Manufactured from stamped steel approved for use in above grade and on-grade floor applications. Boxes shall have the ability to accept a component (FP-CTR) that will allow the box to be installed in polished concrete or terrazzo floors. Boxes shall be painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and be approved for use on-grade and above grade floors. Boxes shall be 7-1/16" L x 6-5/8" W x 4-1/8" H [179mm x 168mm x 105mm]. Provide boxes with provisions that enable installation into concrete floors, raised floors, or wood floors without having to purchase additional components or accessories. Provide boxes with two (2) independent wiring compartments that allow for power, communication and/or audio/video services. Each of the two (2) wiring compartments shall have a minimum wiring capacity of 64-1/2-in³ [1056ml]. The box shall be equipped with a metal divider to separate the services and maintain code requirements. The box shall contain the following number of knockouts: four (4) 1/2-inch trade size, four (4) 3/4"-inch trade size, one (1) 1-inch trade size, six (6) 1-1/4-inch trade size, one (1) 1-1/2-inch trade size, and two (2) 2-inch. Boxes shall be fully adjustable, accommodating a maximum 2-inch [51mm] pre-concrete pour and a maximum 1/2" [12.7mm] post-concrete pour adjustment.

2.4 FLOOR BOX ACTIVATION COVERS

A. Evolution EFB610BT and EFB610CT Series Covers: Manufactured of die-cast aluminum. Activation covers shall be available in surface mount and flush versions. Provide covers with two (2) gaskets (one (1) for carpet and one (1) for tile) to go under the trim flange to maintain scrub water tightness. Covers shall be 16-15/16" x 12-1/2" x 3/16" [430mm x 318mm x 4mm]. Covers shall be available with a carpet recess area or a solid lid. Secure the cover to the flange and enable cover to rotate greater than 180 degrees to reduce trip hazards and provide maximum amount of working space. Provide covers with spring-loaded self-closing slide egress doors to reduce egress opening when cables are exiting and reduce trip hazards. Each of the two (2) egress openings shall have a minimum of 4-in² [102mm²], or a minimum of 8-in² [203mm²] per cover assembly. Cover finish shall be as follows:

B. FloorPort FPFFTC Series Covers: Manufactured of die-cast aluminum or die-cast zinc, and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass). Activation covers shall be available in flanged version. Covers shall come equipped with one (1) 1-inch trade size screw plug opening and one (1) combination 1-1/4-inch and 2-inch trade size screw plug.

2.5 FLOOR BOX COMMUNICATION MODULES MOUNTING ACCESSORIES
2.6 POKE-THRU DEVICES

A. Manufacturer – The Evolution Poke-Thru Devices described shall be manufactured by Wiremold/Legrand. The poke-thru device shall be compatible with the complete line of Ortronics® workstation connectivity outlets and modular inserts, or the Pass & Seymour Network Wiring System. Poke-thru devices of other manufacturers may be considered, if equal in functionality and quality, by written approval of the specifying engineer and shall meet all the performance standards specified herein. The same manufacturer shall provide all poke-thru types for the project. In addition, the contractor shall have ten days prior to the date for receipt of bids to submit to the specifying engineer a working sample from any other manufacturer.

B. (PT TYPE 1) 6AT Poke-Thru Assembly – This assembly consists of an insert and an activation cover. Overall poke-thru assembly length shall be 16 3/4" [425mm].

1. Insert:

   a. The insert body shall recess the devices a minimum of 2 3/4" [69 mm] and have a polyester based backing enamel finished interior (ivory). There shall be the necessary channels to provide complete separation of power and communication services. There shall be three compartments that allow for up to three duplex receptacles that can be wired as a standard receptacle or isolated ground and/or twelve communication ports and/or ten of Extron® Electronics MAAP™ and/or two AAP™ devices.

   b. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain fire rating of the unit and the floor slab. The insert shall have retaining feature that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of a 3/4" trade size conduit stub that is connected to the insert body and a 24.5 cu. in. [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru device to the system ground.

2. Activation Cover – The activation covers shall be manufactured of die-cast aluminum alloy and be available in powder-coated gray, black, or plated in brass, nickel or bronze finish. Two gaskets (one for carpet and one for tile) are provided to go under the trim flange to maintain scrub water tightness. The activation cover shall be 7 1/4" [184mm] in diameter. The activation covers shall be available in carpet and tile versions. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The cover shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.

3. Communication Modules Mounting Accessories – The activation shall have three locations to mount communication connectors. Connectors shall be mounted using a mounting bracket. Mounting brackets shall be provided to mount up to twelve Ortronics TracJack Category 6 insert modules or TechChoice™ Category 6 discrete keystone connectors. The unit will also be supplied with two Category 6 keystone connectors and two Lucent® keystones. The unit shall also accommodate a mechanism to permit protection of communication cabling. This mechanism shall be stamped steel construction and accept both flexible and rigid conduit. This mechanism shall accept 3/4", 1-1/4" or 2" trade size conduits.

C. (PT TYPE 2) 8AT Poke-Thru Assembly – This assembly consists of an insert and an activation cover. Overall poke-thru assembly length shall be 16 3/4" [425mm].

1. Insert:
a. The insert body shall recess the devices a minimum of 2 3/4" [69 mm] and have a polyester based backing enamel finished interior (ivory). There shall be the necessary channels to provide complete separation of power and communication services. There shall be five compartments that allow for up to five duplex receptacles that can be wired as a standard receptacle or isolated ground and/or twenty-two communication ports and/or sixteen of Extron® Electronics MAAP™ and/or four AAP™ devices.

b. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain fire rating of the unit and the floor slab. The insert shall have retaining feature that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of a 3/4" trade size conduit stub that is connected to the insert body and a 24.5 cu. in. [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru device to the system ground.

2. Activation Cover – The activation covers shall be manufactured of die-cast aluminum alloy and be available in powder-coated gray, black, or plated in brass, nickel or bronze finish. Two gaskets (one for carpet and one for tile) are provided to go under of the trim flange to maintain scrub water tightness. The activation cover shall be 9 1/4" [235mm] in diameter. The activation covers shall be available in carpet and tile versions. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The cover shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.

3. Communication Modules Mounting Accessories – The activation shall have three locations to mount communication connectors. Connectors shall be mounted using a mounting bracket. Mounting brackets shall be provided to mount up to twelve Ortronics TracJack Category 6 insert modules or TechChoice™ Category 6 discrete keystone connectors. The unit will also be supplied with two Category 6 keystone connectors and two Lucent® keystones. The unit shall also accommodate a mechanism to permit protection of communication cabling. This mechanism shall be stamped steel construction and accept both flexible and rigid conduit. This mechanism shall accept 3/4", 1-1/4" or 2" trade size conduits.

2.7 FLAT PANEL DISPLAY IN-WALL STORAGE BOX

A. Classification and Use: In-Wall Storage Boxes shall have shall have been tested by Underwriters Laboratories Inc. and classified for fire resistance and bear the U.S. UL Classification Mark. In-wall storage boxes shall be suitable for use in air handling spaces in accordance with Section 300-22 (C) of the National Electrical Code.

B. (FPD TYPE 1) Model PAC525FCW In-Wall Storage Box with Flange and Cover: Manufactured from stamped steel approved for use in standard 3.5" stud and 2.5" stud walls with the same product. Box shall have a finished interior, black in color. Boxes shall be 9" H x 14.25" W x 3.9" D [228.6mm x 361.95mm x 99.06mm]. Knockouts shall be provided for single gang outlets and 1-1/4" & 1/2" conduit. Box shall have universal zip tie anchor points. Box shall be provided with a paintable flange and cover. Cover shall include tamper proof security and include four knockouts for cable routing and ventilation.

1. Provide with Raco 560 3" x 2" box, 2-3/4" deep electrical box.

2. Provide with Raco 864 single duplex electrical box cover.
2.8 WALL JUNCTION BOXES

A. All device boxes for communications systems shall be extra-deep designation.

B. Sheet Metal Junction Boxes: NEMA OS 1, UL 514A, galvanized steel with stamped knockouts.

C. Wall mounted communication boxes concealed within the wall shall be a minimum 4-11/16” square with a minimum depth of 3” with reducer device plate per schedule.

D. AV Plate Junction Box (AVP TYPE 3) Raco Model 263 Electrical Junction Boxes shall be 3-1/2” Deep, 6” Square with (6) 1/2”-3/4”, (2) 3/4”-1” and (2) 1”-1-1/4” side knockouts and (2) 1/2”-3/4”, (2) 3/4”-1” and (2) 1-1/4” bottom knockouts. Box shall be provided with Raco 793 three gang device cover.

E. Camera Junction Box (CAM) Raco Model 260 Electrical Junction Boxes shall be 3-1/4” deep, 4-

F. Projector (PRJ) Raco Model 260 Electrical Junction Boxes shall be 3-1/4” deep, 4-11/16” square with (2) 1/2”-3/4”, (2) 3/4”-1” and (2) 1-1/4” side knockouts and (2) 1/2” & (2) 3/4”-1” bottom knockouts. Box shall be provided with Raco 818 two gang device cover.

G. Sound Reinforcement Speaker Junction Box (S) Raco Model 260 Electrical Junction Boxes shall be 3-1/4” deep, 4-11/16” square with (2) 1/2”-3/4”, (2) 3/4”-1” and (2) 1-1/4” side knockouts and (2) 1/2” & (2) 3/4”-1” bottom knockouts. Box shall be provided with Raco 843 single gang device cover.

H. Wall Control Panel Junction Box (WCP TYPE 1) Raco Model 260 Electrical Junction Boxes shall be 3-1/4” deep, 4-11/16” square with (2) 1/2”-3/4”, (2) 3/4”-1” and (2) 1-1/4” side knockouts and (2) 1/2” & (2) 3/4”-1” bottom knockouts. Box shall be provided with Raco 843 single gang device cover.

I. Specific-use Wall Junction Boxes:

1. For situations where oversized conduit is used so a standard 4-11/16”x4-11/16” box is inadequate for the terminations required, use:
   a. Hubbell Recessed Wall Mounted Gang – WSCS-MMO-X per schedule, or approved equal.

2.9 PULL BOXES

A. Small Sheet Metal Pull Boxes: NEMA OS1; galvanized steel

B. Minimum size:

1. 4” square by 2.125” deep for use with 1” conduit and smaller
2. 4-11/16” square by 3” deep for use with 1-1/4” conduit and larger.

C. Maximum size:

1. 24” square by 8” deep for collecting multiple 1” station conduit. Sheet metal boxes larger than 12” in any direction are required to have a hinged cover or a chain installed between box and cover.
D. Manufacturers: Hoffman Enclosures or approved equal. Field fabricated boxes are not allowed.

E. Floor Mounted Rack Pull Box (FRK) Hoffman Item #ASE16X14X4NK 16” x 14” x 4” deep square pull box. Box shall be provided with screw cover.

F. Millwork Mounted Rack Pull Box (MRK) HOFFMAN ASE8x9x3 8” x 9” x 3” NEMA 1 pull box. Box shall be provided with screw cover.

G. Wall Mounted Rack Pull Box (WRK) Hoffman Model ASE16X14X3 16” x 14” x 3” screw cover pull box at wall behind rack.

H. Paging Speaker Pull Box (PS) – Hoffman Model ASE4X4X3 4” x 4” x 3”.

I. Sound Reinforcement Loudspeaker (S) – Hoffman Model ASE4X4X3 4” x 4” x 3”

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine conditions under which boxes, poke-thrus’ fittings, and projection screens are to be installed and substrate that will support boxes. Notify the Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

1. Do not begin installation until substrates have been properly prepared.

2. Verify rough-in openings are properly prepared.

3.2 DOCUMENT INTERPRETATION

A. The locations of the outlet symbols shown in the Drawings represent a close approximation of the exact location where the outlet shall be installed. This location may be shifted left or right eight inches to allow for stud alignment or coordination with electrical outlet locations. Approval by Owner is required for more extensive adjustments to outlet location.

B. Outlet Schedule

1. Refer to the outlet schedule contained [on the Drawings sheet XXX] for outlet mounting height, device box size, and station conduit size.

3.3 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.4 INSTALLATION

A. Strictly comply with manufacturer’s installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

B. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer’s installation sheets.
C. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.

D. Unused Openings: Close unused box openings using manufacturers recommended accessories.

E. Provide a minimum concrete pour depth of 3-7/16-inch [87mm] plus 1/16-inch [1.6mm] above the top of the box for the RFB4, RFB4-4DB, RFB2, and the RFB2-OG Series Boxes; 2-7/16-inch [62mm] plus 1/16-inch [1.6mm] for the RFB4-SS and RFB2-SS Series Boxes; and 3-7/16-inch [87mm] plus 13/16-inch [21mm] above the top of the box for the RFB4-CI-1, RFB6, and RFB6-OG Series Boxes; and 4-1/16-inch [103mm] above the top of the RFB4E and RFB4E-OG Series Boxes; and 4-inch [102mm] above the top of the RFB6E and RFB6E-OG Series Boxes. Provide the box with four (4) locations to accommodate leveling for pre-concrete pour adjustment and include four (4) leveling screws for the pre-pour adjustment.

F. The 6AT, and 6ATCFF units shall mount in a 6" [152mm] cored hole, actual 6 1/16" [154mm] core hole. The 8AT units shall mount in an 8" [203mm] cored hole, actual 8 1/16" [205mm] core hole. Use is defined by the UL Fire Resistance Directory as a minimum spacing of “2 ft. [610mm] on center and not more than one device per each 65 sq. ft. [6m²] of floor area in each span”.

1. Installation shall be completed by pushing unit down into the cored hole. Prior to and during installation, refer to system layout and/or approval drawings. Installer shall comply with detailed manufacturer’s instruction sheet included with each device. The unit shall contain a retainer for securing the device in the slab, as well as the necessary intumescent material to seal the cored hole under fire conditions.

G. Outlet Box Mounting:

1. Station cable boxes shall be 4-11/16" square x 3" deep regardless of cable count or cable type.

2. Height: unless otherwise noted in the Outlet Schedule, all communication outlet boxes shall be installed at the same height as electrical outlets, except WCP outlets, which shall be installed at 48 inches AFF to center of box.

3. Install boxes to accommodate device indicated by symbol, in conformance with code requirements and consistent with type of construction.

4. Install the appropriate work cover on all outlet boxes.

5. Set front edge of device box flush with the finished surfaces except on walls of non-combustible materials where the boxes may have maximum set back of ¼". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

6. Set outlet boxes parallel to construction and independently attached to same.

7. Do not install back-to-back and through-the-wall boxes. Install with a minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic rated walls.

8. Outlet boxes for audiovisual shall be in a separate box from electrical outlets.

H. Box Support:

1. Mount boxes straight and plumb.
2. Install stud support one side, with short piece of stud, for up to 2-Gang device boxes.

3. Do not support boxes with tie-wire.

4. For one- and two-gang box support, manufactured bracket supports shall be accepted alternate.

5. Support boxes independently of raceways.

6. Install adjustable steel channel fasteners for hung ceiling outlet boxes.

7. Install stamped steel bridges to fasten flush-mounted junction box between studs.

8. Do not install boxes to ceiling support wires or other piping systems.

9. When boxes are installed in fire-resistive walls and partitions, provide 24” horizontal separation between boxes on opposite sides of a wall. In addition, limit penetrations to 16 square inches per penetration and not to exceed a total of 100 square inches per 100 square feet of wall area. Apply fire stop putty or muffins acceptable to the authority having jurisdiction (AHJ).

I. Projection Screen Installation

1. Install in accordance with manufacturer's instructions.

2. Install front projection screens with screen cases in position and relationship to adjoining construction as indicated, securely anchored to supporting substrate, and in manner that produces a smoothly operating screen with plumb and straight vertical edges and plumb and flat viewing surfaces when screen is lowered.

3. Test electrically operated units to verify that screen, controls, limit switches, closure and other operating components are in optimum functioning condition.
3.5 CLEANING AND PROTECTION
   
   A. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
   
   B. Protect boxes and fittings until acceptance.

3.6 STORAGE AND HANDLING
   
   A. Schedule delivery to minimize delays in the project.
   
   B. Provide storage protection against temperature and humidity extremes, theft, vandalism, physical damage, and environmental damage.
SECTION 28 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
3. System smoke detectors.
4. Nonsystem smoke detectors.
5. Heat detectors.
7. Firefighters’ two-way telephone communication service.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.

1.3 DEFINITIONS

A. LED: Light-emitting diode.


1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

B. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 SUBMITTALS

A. General Submittal Requirements:
1. **Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.**

2. Shop Drawings shall be prepared by persons with the following qualifications:
   
   a. Trained and certified by manufacturer in fire-alarm system design.
   b. NICET-certified fire-alarm technician, **Level IV** minimum.
   c. Licensed or certified by authorities having jurisdiction.

B. **Product Data:** For each type of product indicated.

C. **Shop Drawings:** For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
   
   2. Include voltage drop calculations for notification appliance circuits.
   3. Include battery-size calculations.
   4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
   5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
   6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
   7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. **Delegated-Design Submittal:** For smoke and heat detectors 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. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
   2. **Design Calculations:** Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. **Qualification Data:** For qualified Installer.

F. **Field quality-control reports.**

G. **Operation and Maintenance Data:** For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   
   1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   3. Record copy of site-specific software.
   4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
a. Frequency of testing of installed components.
b. Frequency of inspection of installed components.
c. Requirements and recommendations related to results of maintenance.
d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

H. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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

E. NFPA Certification: Obtain certification according to NFPA 72 by.

F. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed or an NRTL alarm company.

1.7 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.
B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fire Control Instruments, Inc.; a Honeywell company.
2. Fire Lite Alarms; a Honeywell company.
3. Gamewell; a Honeywell company.
4. NOTIFIER; a Honeywell company.
6. SimplexGrinnell LP; a Tyco International company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

2. Heat detectors.
3. Flame detectors.
4. Smoke detectors.
5. Duct smoke detectors.
6. Verified automatic alarm operation of smoke detectors.
7. Automatic and pre-action sprinkler system water flow.
8. Heat detectors in elevator shaft and pit.
10. Fire standpipe system.
11. .

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Recall elevators to primary or alternate recall floors.
12. Activate emergency lighting control.
14. Record events in the system memory.
15. Record events by the system printer.
16. Transmit an alarm signal to the Building energy management system.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
   1. Valve supervisory switch.
   2. Low-air-pressure switch of a dry-pipe sprinkler system.
   3. Elevator shunt-trip supervision.
   4. Pre-action sprinkler system.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
   1. Open circuits, shorts, and grounds in designated circuits.
   2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
   3. Loss of primary power at fire-alarm control unit.
   4. Ground or a single break in fire-alarm control unit internal circuits.
   5. Abnormal ac voltage at fire-alarm control unit.
   7. Failure of battery charging.
   8. Abnormal position of any switch at fire-alarm control unit or annunciator.
   9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
  10. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:
   1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
      a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
      b. Include a real-time clock for time annotation of events on the event recorder and printer.
   2. Addressable initiation devices that communicate device identity and status.
      a. Smoke sensors shall additionally communicate sensitivity setting.
      b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
   3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at Trinity Valley Community College DIGITAL, ADDRESSABLE FIR-ALARMS SYSTEMS 50% CD'S / GMP Pricing
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fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Install no more than 50 addressable devices on each signaling line circuit.

D. Stairwell Pressurization: Provide an output signal using an addressable relay to start the stairwell pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.

1. Pressurization starts when any alarm is received at fire-alarm control unit.
2. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.

E. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification Appliance Circuit: Operation shall sound in an industry acceptable pattern.

G. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.
   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.
2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in

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smoke barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center.

1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.

   a. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
   b. Programmable tone and message sequence selection.
   c. Standard digitally recorded messages for "Evacuation" and "All Clear."
   d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

L. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

M. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.


O. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate
response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
   1. Mounting: **Twist-lock base interchangeable with smoke-detector bases.**
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.

B. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-momenting assembly, equipped for mounting as indicated and with screw terminals for system connections.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464.
test protocol.

D. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:
   a. 110 cd.

2. Mounting: Wall mounted unless otherwise indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

4. Flashing shall be in a temporal pattern, synchronized with other units.

5. Strobe Leads: Factory connected to screw terminals.

6. Mounting Faceplate: Factory finished, red or white, as selected by Architect.

E. Voice/Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.

2. High-Range Units: Rated 2 to 15 W.


4. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 FIREFIGHTERS’ TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit, the fire command center, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:

1. Common-talk type for firefighter use only.

2. Selective-talk type for use by firefighters and fire wardens.

3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.

4. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.

5. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.

6. Display: Liquid-crystal digital to indicate location of caller.

7. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.

   a. Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."

   b. With "break-glass" type door access lock.


9. Handsets: push-to-talk-type sets with noise-canceling microphone stored in a cabinet in the fire command center.
2.9 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorknob.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.

B. Material and Finish: Match door hardware.

2.10 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.11 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install system in accordance with NFPA Standards referenced in Parts 1 and 2 of this Section.

B. Fire Alarm Power Supply: Circuit from 1P20A lockable circuit breaker in low voltage panel with 2#10 & 1#10G - 3/4". Paint red and label "FIRE ALARM."

C. Coordination with Architectural Design: All fire alarm device locations to be coordinated with Architect and Engineer for aesthetic purposes. General intent is to align devices with other electrical boxes, outlets, switches, etc. to provide a uniform installation. Provide additional devices where necessary to adhere to alignment requirements.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

C. Smoke- or Heat-Detector Spacing:
3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
5. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

F. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

G. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

H. Water Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

L. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated air-conditioning duct systems.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
10. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
11. Supervisory connections at fire-pump engine control panel.

3.4 WIRING INSTALLATION

A. Wiring Method: Install wiring in metal raceway in accordance with Division 16 Section, RACEWAYS. Conceal raceway except in unfinished spaces and as indicated.

B. Wiring Within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved crimp-on terminal ring lugs. All wiring shall be color coded and each conductor shall be furnished with a wire marker.

C. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.

D. Alarm Wiring: For the low-voltage portion of the fire alarm system, install No. 16 AWG conductors and 90 degree C insulation in wet, damp, or dry locations. Provide wiring operating at line voltage as minimum No. 12 AWG size having similar insulation.

E. Color Coding: Color code all fire alarm conductors differently from the normal building power wiring. Provide one color code for alarm circuits wiring and a different color code for supervisory circuits. Provide a color code for audible alarm indicating circuits different from alarm initiating circuits. Use different colors for visual alarm indicating devices. Paint fire alarm system junction boxes and covers red.

F. Wiring to Central Station Transmitter: Provide a 1-inch conduit between the FACP and the MDF room. Provide number of conductors and electrical supervision for connecting wiring as required to suit central-station monitoring function.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.
3.6  GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.7  FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Commissioning Agent and authorities having jurisdiction.

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

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
   b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.


3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

5. Test visible appliances for the public operating mode according to manufacturer's written instructions.


D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.
3.8 DEMONSTRATION

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

END OF SECTION
SECTION 311000
SITE PREPARATION

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not inclusive but listed as a guide, shall include:
   1. Furnishing of all labor, tools, equipment and incidentals required to complete the work.
   2. Layout of work.
   3. Protection of existing trees.
   4. Removal of trees and other vegetation.
   5. Topsoil stripping.
   6. Clearing and grubbing.
   7. General site excavation.
   8. Removing below-grade improvements.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing related work include but are not limited to the following:
   1. Erosion Control - Section 312500
   2. Tree Protection – 015639

1.3 REFERENCES
Meet requirements and recommendations of applicable portions of Standard listed.
A. ASTM D698 - Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 lb/ft²).
C. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets, and Bridges, 2004

1.4 SUBMITTALS
A. Samples:
   1. Provide adequate samples for determination of moisture density relationships and Plasticity Index (P.I.) of on-site materials, imported fill material and drainage aggregate.
B. Tests Reports: Submit complete laboratory analysis of soil material proposed for fill material.
   1. Establish moisture density relationship of in-place sub-grade in accordance with ASTM D-698.
   2. Establish moisture density relationship of proposed select fill(s) material in accordance with ASTM D-698.
   3. Perform PI test on proposed select fill material to confirm conformance with the project specifications in accordance with ASTM D-4318.

1.5 JOB CONDITIONS
A. Traffic: Conduct site clearing operations to ensure minimum interference with roads, streets, walk, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from the Owner.

B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.

C. Protect improvements on adjoining properties and on Owner’s property.
1.6 NOTIFICATION OF OWNERS OF UTILITY LINES AND EQUIPMENT
   A. Notify any corporation, company, individual or local authority owning conduits, wires, pipes or equipment on site that is affected by demolition work.
   B. Arrange for removal or relocation of indicated items and pay any fees or costs in conjunction with removal or relocation, except as otherwise noted.
   C. Cap lines in accordance with instructions of governing authorities or Owners.

1.7 EXPLOSIVES
   Use of explosives is strictly prohibited.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS
   A. Existing Top Soil to be Stripped: See Section 31 23 15
   B. Select Fill: Shall be select non-expansive sandy clay or clayey sand fill with a Plasticity Index (P.I.) of 4 to 12 and a Liquid Limit of 30% or less.
   C. Sand: Sand for wall backfill shall be pit run, free of organic matter, clays or other binders (concrete sand) with less than 10% passing the #200 mesh sieve.
   D. Non-select Fill: On-site clay material free of debris and vegetation processed so that clods or particles are a maximum of 2" in diameter.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Verify that abandoned utilities have been properly disconnected and capped.
   B. Verify that required barricades and other protective measures are in place.

3.2 DEMOLITION OPERATIONS
   A. Execute demolition of designated existing site items.
   B. Materials, equipment and debris resulting from demolition operations shall become property of Contractor, unless otherwise noted. Immediately remove demolition debris from site and legally dispose.
   C. Provisions for Drainage: If it is necessary in the execution of the work to interrupt the natural drainage of the surface, or the flow of artificial drains, the Contractor shall provide temporary drainage facilities that shall prevent damage to public or private interest and shall restore the original drains as soon as the work shall permit. The Contractor shall be held liable for all damages which may result from neglect to provide for either natural or artificial drainage which his work may have interrupted.

3.3 SALVAGE
   A. Salvage designated site items for relocation and reinstalation.
   B. Store and protect items until ready for installation.

3.4 CLEARING AND GRUBBING
   A. The designated area shall be cleared of all trees, brush, shrubbery, plants, etc., not indicated on the plans to be preserved. Concrete shall be removed where indicated. Trees and brush designated to be left in place shall be carefully trimmed as directed and shall be protected from scarring, barking or other injuries during construction operations. Pruned limbs over two inches in diameter shall be treated by painting the exposed ends with an approved asphaltic material. Unless otherwise indicated on the plans, trees and stumps shall be cut off or otherwise removed as close to the natural ground as practicable on areas which are to be covered by at least three feet of embankment. On areas required for borrow sites and materials sources, stumps, roots, etc., shall be removed to the complete extent necessary to prevent such objectionable matter becoming mixed with the material to be used in construction.
   B. Refer to Section 01 56 39 for tree protection and maintenance requirements.
C. **Existing Bermuda Grass:** In areas of existing bermuda grass where topsoil is to be stripped and stockpiled for reuse on site, remove and dispose of upper 4 inches of soil and bermuda grass.

### 3.5 GENERAL SITE EXCAVATION

A. **The term Building area shall mean the area generally within a line 5 feet from all exterior building wall lines and includes walks abutting the building or walks within the building area.**

B. **The entire building and paving site shall be cleaned of all debris, vegetation, organic matter, concrete and asphalt paving to a depth of 4” minimum before excavation is begun.**

C. **Perform the necessary cutting of the site to establish the grade indicated on the Grading Plan. Cutting shall be sufficiently deep to allow for fill materials to be placed on top of cut area with the finish top soil or paving material to attain the final finish grades.**

D. **After acceptance of exposed cut surfaces by the Testing Laboratory, the exposed surface shall be proof-rolled. Soft, loose areas shall be removed to a level of stiff or dense soil. Backfill with acceptable select fill, moisture condition and compact as required by these specifications and the plans.**

E. **Areas designated for planting or within the limit of construction not covered by building or pavements shall be held down 6” below finish grade for topsoil placement.**

F. **General Demolition:** Shall consist of removal and disposal of pavements and other obstructions visible at the ground surface, underground structures and utilities indicated to be demolished and removed. Legally remove all such excavated materials from site.

G. **Unauthorized Excavation:** Consists of removal of materials beyond indicated subgrade elevations or dimensions without prior approval by Architect/Engineer. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending the indicated bottom elevation of the footing or base to the excavation bottom, without altering required top elevation. Backfill and compact unauthorized excavations as specified for authorized excavations of same classification.

### 3.6 BACKFILL AND FILL - GENERAL

A. **Surface Preparation for Fill:** Scarify soil to a depth of 6”, moisture condition the soil at optimum moisture. Compact to 95% of Standard Proctor at moisture contents at or above the Proctor optimum.

B. **Backfill and Fill:** Place backfill and Select Fill materials in 9” loose lift. Before compaction, bring soil to optimum moisture. Compact each layer to required percentage of maximum density for each area of classification. Do not place backfill material on surfaces that are muddy or frozen.

### 3.7 NOT USED

### 3.8 MAINTENANCE

A. **Protect newly graded areas from traffic and erosion and keep free of trash and debris.**

B. **Repair and re-establish grades in settled, eroded and rutted areas to required finish elevations.**

C. **When completed, compacted areas are disturbed by subsequent construction operations or adverse weather, scarify the surface, reshape and compact to the required density prior to further construction.**

### 3.9 DISPOSAL OF SPOILAGE AND CLEANOUT:

A. **All materials excavated or scheduled to be removed from the site, including, but not limited to concrete paving, asphalt paving, natural soils, abandoned utilities, rock, etc. shall be legally disposed of off the site by the Contractor.**

B. **During the course of the construction, the site shall be maintained free of excavated materials, spoilage, etc. and shall be kept clean and neat at all times.**

END OF SECTION
PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not all inclusive but listed as a guide shall include.
1. Furnishing of all labor, tools, equipment and incidentals to complete the work.
2. Layout of the work.
3. All required excavation within the limits of the work area.
4. Removal, proper utilization or disposal of all excavated material.
5. Compacting, shaping and finishing of all subgrade in conformity to the alignment, cross section, and elevation shown on the plans.
6. Sprinkling for dust control.

B. Submit complete laboratory analysis of soil material proposed for fill material.
1. Establish moisture density relationship of in-place sub-grade in accordance with ASTM D-698.
2. Establish moisture density relationship of proposed select fill(s) material in accordance with ASTM D-698.
3. Perform PI test on proposed select fill material to confirm conformance with the project specifications in accordance with ASTM D-4318.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing related work include but are not limited to the following:
1. Earthwork – Section 31 23 15
2. Lime Treated Subgrade - Section 32 11 29
3. Excavation and Backfill for Conduits – Section 31 23 34

1.3 REFERENCES
Meet requirements and recommendations of applicable portions of Standards listed.

A. ASTM D698 - Laboratory Compaction Characteristic of Soil Using Standard Effort (12,400 lb/ft²).
C. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets, and Bridges, 2004, TxDOT.

PART 2 - PRODUCTS
n/a

PART 3 - EXECUTION

3.1 GENERAL: After the excavation or embankment has been substantially completed, the subgrade shall be brought to the proper alignment, cross-section and elevation, so that after rolling and subsequent finishing operations, it shall conform to the correct configuration and dimensions as indicated on plans.

3.2 EQUIPMENT: All equipment necessary for the construction of this item shall be suitable for the work considering the confined work area and shall be approved by the engineer as to condition before the contractor shall be permitted to begin construction operations on which the equipment is to be used. Hand operated mechanical tampers may be used.
3.3 COMPACTION: Compaction shall consist of the equipment operation, as herein specified discretion.

A. Compaction Methods: The method of compaction shall be left to the discretion of the contractor. Each layer of fill, if dry, shall be wetted uniformly to the moisture content required to obtain the desired density and shall be compacted by means of tamps or rammers.

3.4 FINISHED SUBGRADE: After completion of the compaction and immediately ahead of the application of pavement, the subgrade shall then be tested with templates or string lines by the Contractor. All irregularities which develop in excess of one-half inch in a length of 16 feet (12.5 mm in 5m) measured longitudinally shall be corrected by loosening, adding or removing material; reshaping; and recompacting by sprinkling and rolling. The completed subgrade shall have a uniform density of not less than of the maximum density, as shown on the plans, determined by ASTM D 698. Moisture content shall be within minus 2 to plus 4 of optimum.

The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required pavement section and established grade, until the pavement is placed, and shall be kept wetted down sufficiently in advance of placing any pavement to ensure its being in a firm and moist condition for at least two inches below surface of the prepared subgrade. Only such subgrade as is necessary for the satisfactory prosecution of the work shall be completed ahead of the placement of pavement. Complete drainage of the subgrade shall be provided at all times.

3.5 SPRINKLING FOR DUST CONTROL: Sprinkling for dust control shall consist of the authorized application of water on those portions of the projects as shown on the plans or as directed and herein specified.

The Contractor shall operate a sprinkler which shall insure the distribution of water in a uniform and controllable rate of application. It shall be the Contractor's continuous responsibility at all times including nights, holidays, weekends, etc., until acceptance of the project by the owner, to maintain the project free of dust in a manner which shall cause the least inconvenience to the public.

3.6 COMPACTION TESTS: The completed subgrade shall be tested for compaction and moisture content at the rate of one test per 10,000 square foot.

END OF SECTION
SECTION 312334
EXCAVATION AND BACKFILL FOR CONDUITS

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
   1. Furnishing of all labor, tools, equipment, materials and incidentals to complete the work.
   2. Layout of work.
   3. Excavation and backfill for underground pipes and conduits.
   4. Trench safety.
   5. Testing.
   6. Clean up.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the work as necessary to maintain satisfactory progress of the Work of other Sections. Other Sections containing related work include but are not limited to the following:
   1. Storm Sewer Line Installation - Section 33 41 00

1.3 REFERENCES
Meet requirements and recommendations of applicable portions of the Standards listed.
A. ASTM C33 - Concrete Aggregates.
C. ASTM D698 - Laboratory Compaction Characteristics of Soil Using Standard Effort.
D. American Society of Testing and Materials, ASTM.

1.4 SUBMITTALS
A. Samples:
   1. Provide adequate samples for determination of moisture density relationship and Plasticity Index (P.I.) of on-site materials, imported fill material and drainage aggregate.

B. Trench Excavation Protection shall be as required by the provisions of Part 1926, Subpart P - Excavations, trenching, and shoring of the Occupational Safety and Health Administrations Standards and Interpretations. Additional information may be obtained from the U.S. Department of Labor Occupational Safety and Health Administration (OSHA), 525 Griffin Square Building, Room 602, Dallas, Texas 75202, (214) 767-4731.

C. Furnish and pay for services of Professional Engineer registered in the State of Texas to prepare detailed plans and specifications for trenching and excavation safety systems to meet the requirements of OSHA and Federal, City, and State Law and regulations. Such documents when prepared shall be separately issued by the Contractor to be included within the Construction Documents.

D. Submit one copy of the trench and safety documents to the Owner.
PART 2 - PRODUCTS

2.1 PIPE BEDDING MATERIAL FOR STORM SEWERS
   A. General: The pipe shall be bedded in accordance with details shown on the plans for the type
      of bedding indicated or specified.
   B. Gravel:
      1. Screened Pit Gravel: Passing 1 inch sieve and retained on 5/8 inch sieve.
      3. The aggregate used shall contain not more than a total of eight percent by weight of
         deleterious substances such as clay, shale or organic matter.

2.2 PIPE BEDDING MATERIAL FOR WATER AND SANITARY SEWER MAINS
   A. Crushed Stone Embedment:
      1. Description: The aggregate shall consist of durable particles of crushed stone; free from
         frozen material or injurious amount of salt, alkali, vegetable matter or other material either
         free or as adherent coating; and its quality shall be reasonably uniform throughout. It
         shall have a wear of not more than 40 percent when tested in accordance with Texas
         TxDOT Test Method Tex-410-A.
      2. Test: When tested by standard laboratory methods, crushed rock embedment for each
         gradation shall meet the following requirements for percentage by weight.

         **Standard Crushed Rock - Aggregate Grade 4**
         | PERCENT          |
         | Retained on 1-1/2 inch sieve | 0%   |
         | Retained on 1 inch sieve     | 0-5% |
         | Retained on 2 inch sieve     | 40-75% |
         | Retained on No. 4 sieve      | 90-100% |
         | Retained on No. 8 sieve      | 95-100% |

         **Fine Crushed Rock - Aggregate Grade 8**
         | PERCENT          |
         | Retained on 2 inch sieve    | 0%   |
         | Retained on 3/8 inch sieve  | 0-5% |
         | Retained on No. 4 sieve     | 35-60% |
         | Retained on No. 8 sieve     | 90-100% |

         **Coarse Crushed Rock**
         | PERCENT          |
         | Passing 1-1/2 inch sieve    | 100% |
         | Retained on 3/4 inch sieve  | 100% |

   B. Granular Material: Granular material shall be free flowing, such as sand or hydraulically graded
      crushed stone fines, or mixed sand and gravel, or sandy loam. The material shall be free from
      lumps, stones over two inches in diameter, clay and organic matter.
   C. Select Material: Select material shall be gravel, fine rock cuttings sand, sandy loam or loam
      free from excessive clay. Rock cuttings shall have no dimension greater than two inches.
   D. Natural Gravel: Natural gravel shall consist of uncrushed stones meeting the requirements for
      wear as outlined in Item 2.2A. The material shall be washed and screened and not have by
      weight more than one percent organic matter, clays or loam are not more than five percent by
      weight of anyone of or combination of slate, shale, schist or soft particles of sandstone. The
      graduation shall be:

         **PERCENT**
         | Passing 1-1/2 inch sieve | 100% |
         | Retained on 3/4 inch sieve | 100% |
E. Sand: Sand shall consist of clean, hard, durable, uncoated grains, free from lumps and organic material. All particles must pass a No. 8 sieve.

PART 3 - EXECUTION

3.1 EXCAVATION

A. General: In general, all excavation shall be made in open cut from the surface of the ground and shall be no greater in width or depth than is necessary to permit the proper construction of the work in accordance with the plans and these specifications. All excavation shall be to the line and grade shown on the plans. The entire foundation area in the bottom of all excavation shall be firm, stable, and at uniform density as nearly as practicable. Unless necessary, materials shall not be disturbed. The final cleaning off and preparing of the foundation area shall be done immediately prior to the placing of the conduit or structures.

1. Trench Bottom Elevation. All trenches for installation of water, storm sewer and/or sanitary sewer lines shall be excavated to a point below the barrel of the pipe for the type of embedment specified.

2. Trench Overcut. Should the Contractor excavate below the plan trench bottom for water or sewer lines, he shall backfill to trench bottom grade shown on the plan with approved aggregate, consolidated and compacted. If the Contractor elects to overcut the trench and use gravel and drain pipe as an underdrain in lieu of or in conjunction with pumping, draining or well pointing, the additional work shall be considered as incidental work; and additional compensation shall not be allowed.

Where the character of the foundation material is such that a proper foundation cannot be prepared at the elevation shown on the plans, the Contractor shall deepen the excavation to where a proper foundation can be prepared. Such material removed shall be replaced with foundation materials and thoroughly compacted in place to the finished grade elevation.

3. Excess Trench Width. When the following maximum trench widths are not maintained to a point of one foot above the top of the pipe, the Contractor shall provide at his expense the next higher class of embedment; or embedment as directed by the Owner which shall provide adequate support.

   a) Width of Trench. The limiting trench width shall be as follow:
      1) For 24-inch pipe and smaller, the trench width shall be taken as 24 inches or O.D. of the pipe plus 16 inches whichever is greater.
      2) For pipe larger than 24 inch size, but not to exceed 72-inch, the trench width shall be taken as equal to the O.D. of the pipe installed plus 24 inches.
      3) For pipe larger than 72-inch (1.8M) size, the trench width shall be taken as equal to the O.D. times plus 1.25 plus 1 ft.

   4) Progress: The Owner shall have the right to limit the amount of trenches that shall be opened, or partly opened, in advance of or following the pipe laying operation. Unless otherwise directed by the Owner, the completion of backfill shall immediately follow the pipe laying. In the event the Contractor fails to comply with this requirements, the Owner may stop the pipe laying until the requirements are met.

B. Excavation Classifications: All excavation is unclassified and involves removal of all materials necessary to permit carrying on the completion of the work. Bidders must satisfy themselves as to the actual existing subsurfaces conditions, including but not limited to the depth, location and sizes of pipe or conduits of various kinds in place.

C. Existing Utilities: The Contractor shall thoroughly familiarize himself with available information regarding existing on-site utilities. He shall uncover critical points prior to beginning any trench excavation. Changes to the drawings due to conflicts with existing utilities require the prior
D. Work Sequence: The Contractor shall schedule his work so that all utilities are fully operational. Maintaining acceptable clearance between utilities will be the responsibility of the Contractor.

3.2 SHORING AND SHEETING

When necessary to prevent caving or unduly hazardous working conditions, or to comply with existing laws, trench walls shall be appropriately braced; or sheeted and braced. Where bracing or sheeting and bracing are used, the trench width shall be increased accordingly, shall be considered as incidental work; and shall not be paid for as a separate item. In wet, saturated or flowing materials where it is necessary to install tight sheeting or cofferdams, wood or steel sheet piling shall be used. All sheeting, shoring and bracing shall have strength and rigidity to withstand the pressure exerted; to maintain the side of the excavation properly in place; and to protect all persons or property from injury or damage. When excavations are made adjacent to existing buildings or other structures, or in paved streets, particular care shall be taken to adequately sheet, shore and brace the sides of the excavation to prevent undermining of, or settlement beneath the structures or pavement. Underpinning of adjacent structures or pavement has become necessary it shall be removed, the void satisfactorily refilled, compacted and the pavement replaced. Wooden sheeting, shoring and bracing shall be left in place where it is adjacent to the pipe embedment for the initial lift of backfill. The removal of all sheeting, shoring and bracing shall be done in such manner as not to endanger or damage either new or existing structures, private or public properties; and so as to avoid cave-ins, or sliding of the banks. All holes or voids left by the removal of the sheeting, shoring or bracing shall be immediately and completely filled and compacted with suitable materials. If, for any reason, the Contractor elects to leave in place the sheeting, shoring or bracing, no payment shall be allowed for such material left in place.

A. Disposal of excavated materials: Suitable excavated materials may be piled adjacent to the work to be used for backfilling. Excavated materials unsuitable for backfilling, or in excess of that required for backfilling, shall be disposed of. Desirable topsoil, sod, etc., shall be carefully removed and piled separately adjacent to the work when required. Excavated materials shall be handled at all times in such manner as to cause a minimum of inconvenience to public travel and to permit safe and convenient access to private and public property adjacent to or along the line of the work. The excavated material in rock which is not suitable material for bedding or backfill shall be disposed of. Suitable selected bedding or backfill material shall be provided at no additional cost to the Owner. The contractor shall indemnify and hold harmless the Owner and all of his officers, agents and employees from all suits, actions or claims of any character resulting from his arrangements for and disposal of soil.

B. Dewatering: The Contractor shall remove all water from any source which may accumulate in the excavation. The embedment or pipe shall not be installed in water. No water shall be allowed to flow through or over unset concrete or through the completed line. All water removed from excavations shall be disposed of in an approved manner, so as not to create unsanitary conditions; nor to cause injury to persons or property; nor damage to the work in progress, and/or not to interfere unduly with the use of streets, private driveways or entrances. Pumping, bailing and draining, underdrains, ditches, etc., shall be considered as incidental work and shall not be paid for as separate items.

3.3 BACKFILL

A. Backfill Procedure: Backfill procedure is that procedure required to return trenches or excavated areas to a satisfactory condition. Such backfilling occurs in two general areas: They are:

1. Areas not subject to vehicular traffic:
2. Areas subjected directly to, or influenced by, vehicular traffic.

The methods of backfilling to be used shall vary with the width of trench, the character of the materials excavated, the method of excavation, the type of conduit and the degree of
compaction required. The placing of backfill shall not begin until the pipe structure has been properly bedded and jointed. The excavation shall be backfilled only with approved material. Backfill is divided into two major categories:

1. Embedment is the material upon which the pipe rests; and which covers sewer and water lines.
2. Trench backfill material is the material required to fill the trench from the top of the embedment to ground elevation or subgrade or a street.

B. Compaction: Compaction of all backfill material shall be performed in a manner that shall not crack, crush and/or cause the installed pipe to be moved from the established grade and/or alignment, as shown on the plans. Satisfactory density shall be obtained at various depths on all backfill material as indicated from random selected test points prior to the required exfiltration or pressure tests that are to be performed on lines being constructed. The required densities shall be at not less than the optimum moisture of the material.

1. Densities - areas subjected to or influenced by vehicular traffic. The trench backfill shall be mechanically compacted to the top of the subgrade in six-inch lifts to at least 95 percent of maximum density as determined by ASTM D698. Moisture content shall be within minus 2 to plus 4 of optimum. The embedment shall be compacted to a density as specified under the description of the embedment required.
2. Densities - areas not subjected to or influenced by vehicular traffic. The trench backfill shall be placed in layers into more than 10 inches in depth (loose measurement) and shall be compacted by whatever means the Contractor chooses, to a density comparable with the adjacent undisturbed material. The embedment shall be compacted to a density as specified under the description of the embedment required.
3. Special situations. In areas specifically designated in the plans and specifications, the entire backfill shall be backfilled and compacted to the density specified.
4. Limitations. Densities as specified shall be obtained as the project progresses. No more than 75 percent of the pipe installation on the project is to be completed until specified compaction and density requirements have been ascertained on backfill material for at least 25 percent of the pipe laid.
5. Compaction methods. The method of compaction shall be left to the discretion of the Contractor with the following exception, unless otherwise specified, provided the degree of compaction is obtained and provided that the pipe is not damaged in the process. Compaction of any backfill material by flooding or jetting shall not be permitted. Hand-operated mechanical tampers may be used.
6. Embedment. The type of embedment to be used for storm sewers, sanitary sewers or water mains shall be as on the plans.

3.4 DISPOSAL OF EXCESS MATERIAL:

A. Excess Excavated Material (soil material free of trees, stumps, logs, brush, roots, rubbish and other objectionable matter which has been accepted by the Owner): Remove excess excavated material from the construction site before Pre-final Inspection. Approved excess material shall be deposited on the Owners property outside the perimeter road as indicated by the Drawings or as directed by the Owner.

B. Waste Material (soil material including trees, stumps, logs, brush, roots, rubbish and other objectionable matter which has not been accepted by the Owner): Remove waste material from the project site before Pre-final Inspection. Legally dispose of material at a licensed site or with written and notarized permission from the property owner for a private disposal site. All costs associated with waste material removal and disposal shall be paid for by the Contractor.

3.5 TESTING

A. Laboratory Testing and Inspection Services: As specified in Section 01 46 00 - Testing Laboratory Services.

END OF SECTION
SECTION 312500

EROSION CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not inclusive but listed as a guide, shall include:
   1. Furnishing of all labor, tools, equipment and incidentals required to complete the work.
   2. Layout of work.
   3. Installation of mulch berm.
   4. Placement of riprap.
   5. Erosion Control matting.
   6. Clean-up.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the Work of other Sections. Other Sections containing related work include but are not limited to the following:
   1. Site Preparation - Section 031000

1.3 REFERENCES
Meet requirements and recommendations of applicable portions of Standards listed.
A. ASTM D698 - Laboratory Compaction Characteristic of Soil Using Standard Effort (12,400 lb/ft^2).
C. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets, and Bridges, 2004

1.4 SUBMITTALS
A. General: Submit the following in accordance with Conditions and Section 01330
B. Product data for drainage piping specialities.
C. Product data for geotextiles and erosion control matting.
D. Product data for soil retention blankets.
E. Product data for compost mulch.

1.5 SUMMARY
A. This work shall consist of furnishing, installing, maintaining, and removing devices to prevent silt leaving the site, either thru inlets or by overland flow around inlets. The quantities of temporary silt fence shown on the plans may be increased or decreased based on weather, construction procedures, and actual site conditions that occurs during construction of the project. Such variations in quantity will not be considered as alterations in the details of construction or a change in the character of the work.

PART 2 - PRODUCTS

2.1 SILT FENCE
A. This specification provides criteria for wire-supported geotextile silt fence as well as a self-supporting geotextile silt fence.
B. Fibers used in the manufacture of geotextiles shall consist of long-chain synthetic polymers, composed of at least 85% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such as that the filaments or yarns retain dimensional stability relative to each other, including selvedges. The geotextile shall be specific for its intended purpose. The geotextile shall be free from any treatments or coating which might adversely alter its physical properties after installation.
C. Geotextile rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements.

D. Posts: Either wood, steel, or synthetic posts may be used. Posts shall have a minimum length of 36 in. plus burial depth and be of sufficient strength to resist damage during installation and to support applied loads.

E. Support Fence: Wire or other support fences shall be at least 32 in. high and strong enough to support applied loads.

F. Prefabricated Fence: Prefabricated fence systems may be used provided they meet all of the above material requirements.

2.2 GEOTEXTILES

A. This specification provides criteria for geotextiles used in erosion control devices other than silt fence.

B. Fibers used in the manufacture of geotextiles shall consist of long-chain synthetic polymers, composed of at least 85% by weight polyolefins, polyesters, or polyamide. They shall be formed into a network such as that the filaments or yarns retain dimensional stability relative to each other, including selvedges. The geotextile shall be specific for its intended purpose. The geotextile shall be free from any treatments or coating which might adversely alter its physical properties after installation.

C. Geotextile rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements.

2.3 SOIL RETENTION BLANKET

A. Short Term Protection:
   1. Description. This item shall govern for providing and placing wood, straw or coconut fiber mat, synthetic mat, paper mat, jute mesh or other material as a soil retention blanket for erosion control on slopes or ditches for short term protection or seeded or sodded areas as shown on the plans.
   2. Soil Retention Blankets. Samples of all soil retention blankets shall be submitted to the Architect prior to use. A current list of qualified materials may be obtained by writing to the Director of Maintenance and Operations, Texas Department of Transportation, 125 E. 11th Street, Austin, Texas 78701-2483. Materials shall be approved by the Architect.

B. Long Term Protection.

Geotextiles.
   1. General. Geotextiles are woven or non-woven synthetic fabrics which are designed to be used for erosion control and soil stabilization applications.
   2. Geotextiles used in Erosion Control and Stabilization Applications: The fabric conform to the following average roll minimum values (lot mean-2 standard deviations), as determined by Federal Highway Administration Task Force 25 guidelines cited below, measured in the weakest direction:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Topic</th>
<th>Erosion</th>
<th>Stabilization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PR</td>
<td>UPR</td>
</tr>
<tr>
<td>ASTM D 4632</td>
<td>Grab Strength(lbs)</td>
<td>90</td>
<td>200</td>
</tr>
<tr>
<td>ASTM D 4632</td>
<td>Grab Elongation</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>ASTM D 4533</td>
<td>Trapezoidal Tear(lbs)</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>ASTM D 751</td>
<td>Burst (psi)</td>
<td>140</td>
<td>320</td>
</tr>
<tr>
<td>ASTM D 751</td>
<td>Puncture (psi)</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>ASTM D 4751</td>
<td>Equivalent Opening Size (EOS) (mm)-soil retention</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For Soils in Which:
50% or less passes a #200 mesh sieve
More than 50% passes a #20 mesh sieve
ASTM D 4491 Permeability (k)

For Soils in Which:

EOS:
Greater than a #30 sieve
Greater than a #50 sieve

Type of Application
Critical/Severe:
k (fabric) > 10k (soil)
Normal Applications:
k (fabric) > k (soil)

*PR:  Protected Application (used in conjunction with a buffer)
UPR:  Unprotected Application (used with no protective buffer)

3. Fasteners. Fasteners shall conform to the manufacturer’s recommendations.

2.4 NOT USED

2.5 TOPSOIL
The topsoil shall be fertile soil, be easily cultivated, be free from objectionable material, have relatively high erosion resistance and be readily able to support the growth of planting, seeding or sodding.

2.6 SOD
The sod shall consist of live, growing Bermuda grass, Buffalo grass, St. Augustine grass where shown on the plans, or other acceptable grass secured from sources which are approved by the Architect. Bermuda grass sod, St. Augustine grass sod, or other grassed as shown on the plans, shall have a healthy virile root system of dense, thickly matted roots throughout the soil of the sod for a minimum thickness of 1 inch. The Contractor shall not use sod from areas where the grass is thinned out, nor where the grass roots have been dried out by exposure to the air and sun to such an extent as to damage its ability to grow when transplanted.

2.7 FERTILIZER
A. Specification Submittal. Submit a sample label or specification of the fertilizer proposed to be used for the Owners approval.
   1. General: Fertilizer shall be a commercial product, uniform in composition, free flowing and suitable for application with approved equipment. Fertilizer shall be delivered to the site in fully labeled original containers. Fertilizer which has been exposed to high humidity and moisture, has become caked or otherwise damaged, making it unsuitable for use, shall be rejected.
   2. Initial Planting Application. Fertilizer for the initial planting application shall be of an organic base containing by weight the following (or other approved) percentages of nutrients: 15-10-5 (N-P-K); also containing 1-15 percent sulphate and traces of iron and zinc as required and approved by the Owner.
   3. Post Planting Application. Fertilizer for the post planting application shall be a chemical base fertilizer containing by weight the following percentages of nutrients: 21-0-0 (N-P-K) ammonium sulphate; or the nitrogen equivalent of 33-0-0 ammonium nitrate.

PART 3 - EXECUTION

3.1 MULCH BERRMS
A. The Contractor shall install a mulch berm as shown on the plans, and at other locations as required. Fence construction shall be adequate to handle the stress from sediment loading.
B. It is the Contractor’s responsibility to maintain the integrity of mulch berms as long as they are necessary to contain sediment runoff. The Contractor shall inspect all mulch berms 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 the mulch berms in areas where construction activities have changed the natural contour and drainage runoff to ensure that the silt fences are properly located for effectiveness. Where deficiencies exist, additional mulch berms shall be installed. Should the mulch berm become damaged or otherwise ineffective while the barrier is still necessary, it shall be repaired promptly.

C. Sediment deposits shall either be removed when the deposit reaches approximately one-half of the height of the mulch berm or a second mulch berm shall be installed.

D. The mulch berm shall remain in place as long as needed. Upon removal, the Contractor shall remove and dispose of any excess silt accumulations, dress the area to give a pleasing appearance, and vegetate all bare areas the berm materials will remain the property of the Contractor and may be used at other locations provided the materials meet their intended purpose.

The designated area shall be cleared of all trees, brush, shrubbery, plants, etc., not indicated on the plans to be preserved. Concrete shall be removed where indicated. Trees and brush designated to be left in place shall be carefully trimmed as directed and shall be protected from scarring, barking or other injuries during construction operations. Pruned limbs over two inches in diameter shall be treated by painting the exposed ends with an approved asphaltic material. Unless otherwise indicated on the plans, trees and stumps shall be cut off or otherwise removed as close to the natural ground as practicable on areas which are to be covered by at least three feet of embankment. On areas required for borrow sites and materials sources, stumps, roots, etc., shall be removed to the complete extent necessary to prevent such objectionable matter becoming mixed with the material to be used in construction.

3.2 SOIL RETENTION BLANKET

Soil retention Blankets shall be installed in accordance with Manufacturers recommendations.

3.3 NOT USED

3.4 HYDRO MULCHING

Seed or seed mixture, in the quantity specified, shall be uniformly distributed over the areas shown on the plans where directed. Seed and fertilizer to be distributed as a water slurry, and the mixture shall be applied to that area to be seeded within 30 minutes after all components are placed in the equipment. After planting, the seed shall be raked or harrowed into the soil to a depth of approximately 1/4 inch (6mm). The planted area shall then be rolled with a smooth roller, developing 15 to 25 psi (100 to 170 kp) contact pressure upon the planted surface area and giving smooth surface without ruts or tracks. After compacting is completed, the planted area shall be watered sufficiently to assure uniform moisture from the surface to a minimum of six inches (150 mm) in depth.

END OF SECTION
SECTION 316329
DRILLED PIERS

PART 1 - GENERAL

1.1 SUMMARY
A. Description of Work: Furnish all labor, materials, services, equipment and appliances required in conjunction with drilled pier foundations complete, including, but not limited to the following:
1. Layout of drilled piers.
2. Excavation of drilled piers.
3. Temporary steel casings – if required.
4. Furnishing and placing reinforcing steel.
5. Furnishing and placing concrete.
6. Placing anchor bolts for steel columns.
7. Removal of spoil (excavated material) resulting from drilled pier excavations.
B. The extent of drilled piers is shown on the drawings, including locations, diameters of shafts, elevation of top bearing stratum for bidding purposes, top of pier elevations, reinforcement, and details of construction.
C. Related work specified in other sections:
1. Testing Laboratory Services: Section 014100.
2. Soil Investigation Data: Section 022000.
3. Concrete Reinforcement: Section 032000.
4. Cast-in-Place Concrete: Section 033000.

1.2 QUALITY ASSURANCE
A. Pier drilling contractor shall be required to submit proof of qualifications requirements including:
1. Minimum of 5 previous projects of similar scope and nature or larger.
2. Verify having been in business for a minimum of three years.
B. Testing laboratory services:
1. Refer to section 014100 for additional information concerning laboratory services in conjunction with drilled pier work.
2. The contractor shall pay for the services of an independent testing agency to design the concrete mix in conjunction with drilled piers and to perform continuous pier drilling observations.
3. Contractor shall give a minimum of 2 days notice to geotechnical consultant for services in conjunction with drilled piers.
C. Drilling Log:
Geotechnical Representative shall keep an exact log of each pier, regardless of soil conditions, indicating:
1. Pier number.
2. Pier location.
3. Depth drilled through overburden.
4. Depth drilled in bearing stratum.
5. Elevation of ground surface.
6. Top elevation of concrete.
7. Top elevation and length of casing.
8. Diameter of shaft.
9. Diameter and type of bell (if bells are required).
10. Estimated inflow of water, source, and depth in bottom of hole when concrete is placed.
11. Description of bearing stratum.
12. Pumping required.

1.3 JOB CONDITIONS
A. Scheduling:
   1. Schedule pier drilling so that piers will be filled with concrete within 8 hours after drilling.
   2. Fill each pier with concrete not later than the same day it is drilled.

PART 2 – PRODUCTS

2.1 DRILLING EQUIPMENT
A. The equipment used shall be adequate to drill the sizes indicated to depths necessary for a stable foundation, giving consideration to subsurface conditions reported by the Geotechnical Investigation.

2.2 MATERIALS
A. Concrete Reinforcement: As specified in Section 032000.
B. Cement, Aggregates and Admixtures: As specified in Section 033000.

2.3 MIXES
A. As specified in Section 033000.

PART 3 – EXECUTION

3.1 CONSTRUCTION
A. Drilling
   1. Drill piers with power auger foundation drilling rig designed for that purpose. Drill piers vertically, to diameters shown on drawings.
   2. If caving or substantial amounts of ground water are encountered, use casings, if required, to prevent caving and exclude water.

B. Casings
   1. Protective steel casing, at least as large in inside diameter as the nominal shaft size and of sufficient wall thickness to resist crushing by hydrostatic and earth pressures, shall be installed in each pier hole when needed, in the judgement of the Foundation Inspector(s), to prevent caving or fall-in.

C. Casing Removal
   1. An initial jerk of “2” to “4” shall be allowed to start the lift; thereafter, while being removed from the pier hole, the casing must be kept plumb and must be pulled with a smooth, vertical motion (no rotation permitted), without jerks. Vibration of the casing during pulling is not approved. Maintain sufficient head of concrete to prevent reduction in diameter of pier shaft by earth pressure and to prevent extraneous material from mixing with fresh concrete. Coordinate withdrawal of temporary casings with concrete placement to maintain a sufficient need of concrete above casing bottom.
   2. Where cutoff elevation is below ground level, maintain protective casing to the ground surface if necessary to prevent detrimental caving or intrusion of shallow soils into the shaft.
   3. Dowels shall be placed and positioned after the casing has been pulled and the surface of the concrete has been established.
D. Removal of Groundwater Seepage
   1. Water above an average depth of 2” above the bottom of the excavation shall be pumped or removed before placement of concrete. If water cannot be held below this level long enough for concrete to be placed in the normal manner, place concrete by one of the following methods:
      a. Use of a submersible pump in the bottom of a straight hole or in a sump excavated in the bottom of a bell, with concrete being placed to cover the intake pipe before the pump is lifted.
      b. Use of a Tremie pipe or “elephant’s truck”.
      c. Use of pumped-in concrete discharging through a pipe below the water and below the surface of the concrete in the hole.

E. Allowable Tolerances:
   1. The piers shall be installed as indicated on the Drawings and in accordance with these Specifications. No pier shall be off center from its design locations more than 1/24 of the shaft diameter or 3”, whichever is less measured at the top of the pier. No vertical pier shall be out of plumb more than 1% of its length. All piers and shafts shall be at least as large in diameter as indicated on the Drawings. Deviations from underream configurations (if required) may be made only with prior written approval of the Structural Engineer.
   2. If any of the above tolerances are exceeded, additional construction (including costs of engineering and redesign) as required by the Structural Engineer, shall be paid for by the Contractor.

3.2 PLACING REINFORCING STEEL AND CONCRETE
   A. Do not place steel or concrete until pier holes have been inspected, logged and approved by the Testing Laboratory.
   B. Reinforcing steel shall be installed as indicated on the Drawings. All steel shall be free from excessive rust, mud or any foreign material which would hinder bonding of concrete and steel. Reinforcement cages shall be straight and shall conform to the design dimensions. Adequate provision shall be made to ensure that the reinforcement steel will remain in place throughout placement of concrete and that specified concrete cover for the reinforcement steel is attained and maintained. The use of precast concrete spacer blocks or “Centraligner” pier sleds by Pieresearch, Arlington, TX (or equal) is recommended for this purpose.
   C. After approval of the excavated pier hole by the Testing Laboratory, concrete shall be placed, if necessary, with the use of a drop chute or tremie, limiting free fall to 25’ maximum, such that will not cause segregation of the particles or permit infiltration of water or any other occurrence which would tend to decrease the strength of the concrete or the capacity of the finished pier. All concrete shall be placed in the presence of the Testing Laboratory.
   D. Maintain a minimum 3” clearance between bottom of excavation and reinforcement.

3.3 DISPOSAL OF SOIL
Remove spoil from the ground around the excavation before concrete placement is started, and dispose off the site in a legal manner.

END OF SECTION
SECTION 321129
LIME TREATED SUBGRADE

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
1. Furnishing of all labor, tools, equipment and incidentals to complete the work.
2. Layout of the work.
3. Treatment of subgrade by the addition of lime.
5. Clean up.

1.2 RELATED SECTIONS
A. Coordinate the Work of this Section with the work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing related work include but are not limited to the following:
1. Subgrade Preparation - Section 312313
2. Earthwork - Section 312315

1.3 REFERENCES
A. American Society for Testing and Materials ASTM.
B. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges, 2004, TxDOT.

PART 2 - PRODUCTS

2.1 GENERAL
A. Base and Subbase Materials: Base and Subbase materials shall meet the requirements shown on the plans or in the pertinent specifications.
B. Lime: The lime shall meet the requirements or Paragraphs 2.2 and 2.3 Hydrated Lime, for the type of lime specified. When Type B, commercial lime slurry, is specified, the Contractor shall select, prior to construction, the grade to be used and shall notify the in writing before changing from one grade to another.
C. If the minimum design strength or percent lime to be used for the treated subgrade, existing base, new subbase or new base is not specified on the plans, it shall be determined by preliminary laboratory tests at the Owners expense.

2.2 HYDRATED LIME (DRY)
A. General. Hydrated lime shall consist of a dry powder. This material is to consist essentially of calcium hydroxide. Hydrated lime shall be stored and handled in closed, weatherproof containers until immediately before distribution on the road. If storage bins are used, they shall be completely enclosed. Hydrated lime bags shall be stored in weatherproof buildings with adequate protection from ground dampness. If provided in bags, each bag shall bear the manufacturers certified weight. Bags varying more than five percent by weight may be rejected, and the average weight of the bags in any shipment, as shown by weighing 50 bags
taken at random, shall not be less than the manufacturers certified weight. If lime is furnished in trucks, each truck shall bear the weight of lime measured on certified scales or the Contractor shall place a set of standard platform truck scales or hopper scales at a location approved by the Owner.

Material. When sampled and tested according to Texas TxDOT Method Tex-600-J, Lime Testing Procedure, hydrated lime shall conform to the following requirements as to chemical composition:

Hydrate Alkalinity, percent by weight Ca(OH) \(_2\) Min. 90.0% Unhydrated lime content, percent by weight CaO Max. 5.0% free Water content, percent by weight H\(_2\)O Max. 4.0%.

The percent by weight of residue retained shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Residue retained on a sieve</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 6 (3360 micron)</td>
<td>0.2%</td>
</tr>
<tr>
<td>No. 10 (2000 micron)</td>
<td>1.0%</td>
</tr>
<tr>
<td>No. 30 (590 micron)</td>
<td>4.0%</td>
</tr>
</tbody>
</table>

2.3 HYDRATED LIME SLURRY

A. Type B, commercial lime slurry is hereby specified. It shall be a pumpable suspension of solids in water. The solids portion of the mixture, when considered on the basis of solids content, shall consist principally of hydrated lime of a quality and fineness sufficient to meet the following requirements as to chemical composition and residue.

B. Materials.

1. Chemical Composition. The solids content of the lime slurry shall have a hydrate alkalinity Ca (OH)\(_2\) of not less than 90 percent by weight.

2. Residue. The percent by weight of residue retained in the Asolid content of lime slurry shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Residue retained on a sieve</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 6 (3360 micron)</td>
<td>None</td>
</tr>
<tr>
<td>No. 10 (2000 micron)</td>
<td>1.0%</td>
</tr>
<tr>
<td>No. 30 (590 micron)</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

C. Type B, commercial lime slurry, shall conform to one of the following three grades:

Grade 1: The dry solids contents shall be at least 31 percent by weight of the slurry.

Grade 2: The dry solids contents shall be at least 35 percent by weight of the slurry.

Grade 3: The dry solids contents shall be at least 46 percent by weight of the slurry.

D. Water. Potable water shall be used.

2.4 QUICKLIME

A. General. Quicklime shall consist of a dry powder in a tank to form a lime slurry and is restricted to Slurry Placing only.
CAUTION: HANDLING AND USE OF QUICKLIME CAN BE DANGEROUS. QUICKLIME SHOULD BE PRESCRIBED BY A REGISTERED PROFESSIONAL ENGINEER FAMILIAR WITH ITS USE.

B. Materials. Quicklime shall conform to the chemical requirements of Quicklime for Structural Purposes, ASTM Designation C5.

PART 3 - EXECUTION

3.1 CONSTRUCTION METHODS:

A. General. It is a primary requirement of this specification to secure a completed course of treated material containing a uniform lime mixture, free from loose or segregated areas, or uniform density and moisture content, well bound for its full depth, and with a smooth surface and suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of this work, to use the proper amount of lime, maintain the work and rework the courses as necessary to meet the above requirements.

Prior to beginning any lime treatment, the pavement subgrade shall be constructed and shaped to conform to the lines and grades as shown on the plans.

1. Treatment for Materials in Place. Materials to be treated shall be excavated to the secondary grade (proposed bottom of lime treatment) and removed or windrowed to expose the secondary grade. Any wet or unstable material below the secondary grade shall be corrected by scarifying, adding lime and compacting until it is of uniform stability. The excavated material shall then be spread to the desired cross section. If the Contractor elects to use a cutting or pulverizing machine that shall remove the subgrade material accurately to the secondary grade and to pulverize the material at the same time, he shall not be required to expose the secondary grade or windrow the material.

However, the Contractor shall be required to proof roll the subgrade before using the pulverizing machine and correct any soft areas that this rolling may reveal. This method shall be permitted only where a machine is provided which shall insure that the material is cut uniformly to the proper depth and which has cutters that shall place the secondary grade to a smooth surface over the entire width of the cut. The machine shall be of such design that a visible indication is given at all times that the machine is cutting to the proper depth.

B. Application. Lime shall be spread only on that area where the first mixing operation can be completed in the same working day. The application and mixing of lime with the materials shall be accomplished by the method hereinafter described as slurry placing unless otherwise approved by the engineer.

1. Dry Placing. The lime shall be spread by an approved screw type spreader box or by bag distribution at the rate shown on the plans.

   The lime shall be distributed at a uniform rate and in such a manner as to reduce scattering of lime by wind to a minimum. Lime shall not be applied when wind conditions are such that blowing lime becomes objectionable to traffic or adjacent property owners. A motor grader shall not be used to spread lime. The material shall be sprinkled until proper moisture content has been secured.

2. Slurry Placing. Lime shall be mixed with water and applied as a thin water suspension or slurry. Type B, commercial lime slurry, shall be applied with a lime percentage not less
than that applicable for the grade used. The distribution of lime at the ratio specified shall be attained by successive passes over a measured surface of roadway until the proper moisture and lime content has been secured.

C. Mixing. Mixing procedure shall be the same for dry placing or slurry placing as hereinafter described.
1. Treatment for Materials in Place. Material and lime shall be thoroughly mixed by approved road mixers or other approved equipment, until a homogeneous, friable mixture of material and lime is obtained free from all clods or lumps. Materials containing plastic clay or other materials which shall not readily mix with lime shall be mixed as thoroughly as possible at the time of the lime application, brought to the proper moisture content, sealed with a pneumatic roller, and left to cure 1-4 days. During the curing period the material shall be kept at its proper moisture curing point.
2. Final Mixing. After curing, the material shall be uniformly mixed. Clods or lumps shall be reduced in size by raking, blading, diskimg, harrowing, scarifying or other pulverizing method so that when all nonslaking aggregates retained on the No.4 sieve are removed, the remainder of the material shall meet the gradation percentages as outlined in NCTCOG Item 4.6

<table>
<thead>
<tr>
<th>Gradation Percentage</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum passing 1-3/4” sieve</td>
<td>100%</td>
</tr>
<tr>
<td>Minimum passing No. 4 sieve</td>
<td>60%</td>
</tr>
</tbody>
</table>

D. Compaction. Compaction of the mixture shall begin immediately after final mixing and in no case later than three calendar days after final mixing. The material shall be aerated or sprinkled as necessary to provide optimum moisture. Compaction shall begin at the bottom and shall continue until the entire depth of the mixture is uniformly compacted as shown on the plans or specified by the engineer. The compacted mixture shall have a uniform density of not less than 95 percent of the maximum density as determined by ASTM D 698. Moisture content shall be to optimum to plus 3 percentage points of optimum. After each section is completed, such tests as are necessary shall be made by a testing agency hired by the Owner. If any portion fails to meet the density specified, it shall be reworked as necessary to obtain the specified density.

3.2 FINISHING, CURING AND PREPARATION FOR SURFACING
After the mixture has been compacted, the surface shall be shaped to the required line, grades and cross sections; and then thoroughly rolled sufficiently light to prevent hair cracking. The completed section shall then be moist-cured for a minimum of seven days before further courses are added or any traffic permitted, unless otherwise directed by the engineer in cases where subgrade treatment or sub-base sets up sufficiently to prevent objectionable damage from traffic, such layers may be opened to traffic two days after compaction. The surface of the compacted layer shall be kept moist until covered by other base or paving materials or application of a curing seal of emulsified asphalt. If a curing seal is used, it should be applied as soon as possible after completion of final rolling, at a rate of between 0.10 and 0.20 gallons per square yard (.5 and 1.0 liters per M5), the exact rate to be determined by the engineer. No equipment or traffic shall be permitted on lime treated material for 72 hours after curing seal is applied, unless otherwise permitted by the engineer.
3.3 MAINTENANCE
The Contractor shall be required to maintain the completed soil lime base within the limits of his contract, in good condition, satisfactory to the engineer as to grade, crown and cross-section until such time as the surface course is constructed. All irregularities or other defects that may occur shall be immediately repaired by the Contractor at his own expense. Repairs are to be made as directed by the engineer in a manner to insure restoration of a uniform surface durability or the portion repaired.

3.4 TESTING
A. The Testing Laboratory shall make continuous on-site visual inspection of lime placement, mixing, watering, and compaction. In addition, the Testing Laboratory shall establish lime moisture and density relationships to stabilized subgrades in accordance with established ASTM procedures and TxDOT standards. Provide the following tests:
1. One Standard Proctor for each 2,000 square feet of area of each type of in-place material or imported fill, ASTM D-698.
2. One gradation test every 10,000 square feet of paving area and at least one test per day. Refer to NCTCOG Item 4 as outlined above.

END OF SECTION
SECTION 321600
CONCRETE CURBS AND GUTTERS

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not at all inclusive but listed as a guide, shall include:
   1. Furnish all labor, tools, equipment and incidentals to complete the work.
   2. Concrete paving, driveway approaches, integral curbs, curbs and gutters, concrete for sidewalks, riprap, manholes, headwalls, steps planters and miscellaneous other uses.
   3. Expansion joint fillers.
   4. Sawed joints.
   5. Sealing of Joints.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing relate work include but are not limited to the following:
   1. Testing and Inspection Services - Section 01 45 23
   2. Earthwork - Section 31 23 15
   3. Pavement Markings - Section 32 17 23
   4. Sidewalks and Driveways Approaches - Section 32 20 00
   5. Concrete Paving – Architectural Finishes - Section 32 13 13

1.3 REFERENCES
A. American Society for Testing and Materials, ASTM.
B. Texas Department of Transportation Standards Specifications for Construction of Highways, Streets and Bridges, 2004, TxDOT.

1.4 PRODUCT HANDLING
A. Protection:
   1. Protect from damage until acceptance.
   2. Exclude traffic for 14 days after placement.

1.5 CONTROL
A. Grade Control: Establish and maintain required lines and grades.
B. Traffic Control:
   1. Maintain vehicular and pedestrian traffic as required for other construction activities.
   2. Provide barricades, warning signs, and warning lights as required to control traffic, maintain safety and cause least interruption of work.

PART 2 - PRODUCTS

2.1 REINFORCEMENT: As noted on Drawings.

2.2 CONCRETE: 3,500 psi at 28 days.

2.3 FORMS:
A. Steel or wood.
B. Straight and free of distortion and defects.
C. Radius Bends: Flexible spring steel or laminated boards.
D. Form Oil: Non-staining, clear, paraffin base.
2.4 FILLERS AND JOINTS:
   Expansion Joints: Premolded joint filler.

2.5 FLY ASH: The use of fly ash will be permitted when the amount and type has been established by laboratory data. The maximum amount allowed shall not exceed 20 percent of absolute volume of the specified cement content.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Proof roll prepared subgrade to check for unstable areas requiring additional compaction.
   B. Do not begin work until any discrepancies have been corrected.
   C. Remove loose material from subgrade immediately prior to placing concrete.

3.2 INSTALLATION
   A. Forms:
      1. Set to required grades and lines.
      2. Brace securely with wood or metal stakes.
      3. Leave in place 24 hours after concrete placement.
   B. Automatic Curb and Gutter Machine:
      1. May be used at the contractor’s option with Owners Representative approval.
      2. Machine placement must produce curbs and gutters equal in all respects to formed concrete.
      3. If results are not acceptable, remove and replace with formed concrete.
   C. Joints:
      1. General:
         a. Expansion, weakened-plane (contraction) and construction joints; true to line, face perpendicular to surface of curb and gutter.
         b. Transverse joints: at right angles to curb center line.
         c. Where joining existing pavement: align transverse joints with existing joints unless otherwise shown.
      2. Expansion Joints:
         a. Locate at 30'-0" o.c. unless otherwise shown.
         b. Provide where curb abuts manholes, inlets, structures, walks or other fixed objects.
         c. Extend joint fillers full width and depth of joints.
         d. Not less than 2 inch or more than 1 inch below finished surface.
         e. Conform top edge to top profile of curb and gutter.
      3. Weakened-plane (Contraction Joints):
         a. Locate at 10'-0" o.c. unless otherwise shown.
         b. Embed strips of metal or sealed wood to form joints.
         c. Set strips in plastic concrete and remove after concrete has hardened.
      4. Construction Joints:
         a. Place at end of all pours.
         b. Located where placement stops for more than 2 hour except where pours terminate at expansion joints.

3.3 FINISHING
   A. Broom Finish:
      1. Draw fine-hair broom across concrete surface perpendicular to line of traffic.
      2. Repeat if required to provide texture suitable to match exiting curbs.

3.4 CLEANING
   A. When construction traffic is permitted, remove surface stains and spillage of materials as they occur.
B. Sweep and wash free of stains, discoloration, dirt and other foreign material just prior to final inspection.

END OF SECTION
SECTION 321723
PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES:
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
1. Furnish all labor, materials, services, equipment and appliances required in conjunction with painted pavement markings.
2. Layout all markings.
3. Four inch (4") white color stripping for parking spaces in parking lots as indicated on site plan.

1.2 RELATED SECTIONS
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing related work include but are not limited to the following:
1. Portland Cement Concrete Paving - Section 32 13 13

1.3 REFERENCES
A. American Society for Testing and Materials, ASTM.
B. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges, 2004, TxDOT.

1.4 QUALITY ASSURANCE
A. Subcontractor for work of this section shall be of firm specializing in application of pavement markings.

1.5 PROJECT CONDITIONS
A. Concrete paving and curbs shall have been in place a minimum of 14 days prior to application of pavement markings.
B. Do not apply marking paint when weather is foggy or rainy, or ambient or pavement temperature are below 40 F, nor when such conditions are anticipated during eight hours after application.

PART 2 - PRODUCTS

2.1 MATERIALS
A. Paint for markings: Equal to Standard Paints, Inc., 1007 W. Commerce Street, Dallas, Texas or Sherwin Williams Traffic Marking Paint, conforming to Fed. Spec. TT-P-115E, Type III, or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine surface on which pavement markings are to be applied and report any unsatisfactory conditions which will prevent the proper application of markings to the Contractor.

3.2 PREPARATION:
A. Thoroughly clean surfaces to receive pavement markings. Layout markings in conformance with drawings. Surfaces to receive markings shall be dry.

3.3 APPLICATION
A. Equipment: Hand operated push-type machines of a type commonly used for application of paint to pavement surfaces. Use hand-operated spray guns in areas where the push-type machines cannot be used.

B. Application: Apply paint in one coat evenly to clean, dry surfaces. Apply marking paint at not less than rate of one gallon per 100 sq.ft. (equivalent to approximately one gallon for 300 lineal feet of 4" wide strip), to result in uniform complete coverage of surfaces to be painted. Apply paint only when air and surfaces temperatures are above 40 F. Provide guide lines and template necessary to control paint application. Edges of markings shall be sharply outlined.

C. Protection: Protect newly painted surfaces from damage by vehicles during time required for paint to harden sufficiently to withstand traffic. During period of high wind, discontinue painting operations.

3.4 CLEANING
A. Cleanup all debris caused by the work of this section, keeping the premises clean and neat at all times.

END OF SECTION
SECTION 322000
SIDEWALKS AND DRIVEWAY APPROACHES

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
1. Furnishing of all labor, tools, materials, equipment and incidentals required to complete the work.
2. Concrete sidewalks, concrete for planters and steps, barrier free ramps, driveways and approaches.
3. Expansion joint fillers.
4. Sawed joints.
5. Sealing of joints.

1.2 RELATED SECTIONS
A. Coordinate the work for this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections. Other Sections containing related work include but are not limited to the following:
1. Testing and Inspection Services - Section 01 45 23
2. Subgrade Preparation - Section 31 23 13
3. Pavement Marking - Section 32 17 23
4. Concrete Formwork - Section 03 10 00
5. Concrete Reinforcement - Section 03 20 00

1.3 REFERENCES STANDARDS
A. American Concrete Institute (ACI)
1. ACI 305-77 - Recommended Practice for Hot Weather Concreting.
2. ACI 306-72 - Recommended Practice for Cold Weather Concreting.
C. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets, and Bridges, 2004, TxDOT.

1.4 QUALITY ASSURANCE
A. Source Quality Control: Testing and Inspection as specified in Section 01410.
B. General: Concrete sidewalks shall have a minimum thickness of four inches; except that sidewalks constructed in driveways approach sections shall have a minimum thickness equal to that of driveway approach or as called by plans and specifications within the limits of the driveway approach. The construction of the driveway approach shall include the variable height radius curb in accordance with the plans and details.
C. Concrete Mix Design Criteria:
1. Contractor shall provide and pay for design of concrete mixes. Design of concrete mixes shall be performed by a testing laboratory selected by Contractor and approved by the architect. Design methods shall be in accordance with ACI 211.
2. For each concrete mix design, make three trial mixes using proposed aggregate, in accordance with ACI 211. Experience Method is acceptable.
3. Check mix designs and revise if necessary wherever changes are made in aggregates or in surface water content of aggregate or workability of concrete.

1.5 JOB CONDITION
A. Environmental Conditions: Replace with same wording in 02514, 1.7A.
B. Allowable Concrete Temperature:
2. Hot Weather: Conform to ACI 305.

PART 2 - PRODUCTS

2.1 MATERIALS
A. Portland Cement: ASTM C150, Type 1.
B. Aggregates: ASTM C33. Refer to Portland Cement Concrete Paving (32 13 13)
C. Admixtures:
D. Fly Ash: The use of fly ash will be permitted when the amount and type has been established by laboratory data. The maximum amount allowed shall not exceed 20 percent of absolute volume of the specified cement content.
E. Water: Clean and potable.
F. Reinforcing Steel:
   1. Bar mats: ASTM A184, Grade 60.
   2. Deformed billet steel: ASTM A615, Grade 60.
H. Dowels and Sleeves: Plain round bar dowels, sized as detailed, conforming to reinforcing steel requirements, coated with bituminous paint on one-half or length. Provide sleeves as detailed, closed at one end, and allowing one inch movement at closed end.
I. Supports: Provide chair spacers and other required supports in accordance with requirements of ACI 315.
J. All expansion joints shall be 1/2 inch redwood.
K. Wood Form: Good grade lumber, sound and free of warp, minimum 2 inch nominal thickness, except where extremely short radius of curves require thinner forms.
L. Curing Compound: Liquid membrane, ASTM C309, Type 2 white pigmented.
M. Curing Sheets: ASTM C171.
N. Joint Sealing Compound: Hot rubber compound or silicone sealing compound.

2.2 CONCRETE MIX
A. Concrete Quality: In accordance with approved mix design and following requirements:
   1. Slump: 5" maximum for flatwork.
   2. Compressive strength: Not less than 3,000 psi at 28 days.
   3. Entrained air: Concrete mix shall contain 5% entrained air plus or minus 1%.
   4. Admixture: Introduce in quantities and according to methods recommended by admixture manufacturer.

PART 3 - EXECUTION

3.1 INSPECTION
A. Verify that earthwork is completed to correct line and grade.
B. Check that subgrade is smooth, compacted and free of frost or excessive moisture.
C. Do not commence work until conditions are satisfactory.

3.2 MAINTAINING SUBGRADE PRIOR TO PLACING CONCRETE
A. Provide complete drainage of subgrade during entire construction period. On elevated grades, direct surface water to gutters, pave ditches or drains by proper grading of subgrade.
B. Maintain subgrade in a smooth, compacted condition at required section and grade until concrete pavement is ready to be placed. Keep subgrade thoroughly wetted down sufficiently in advance of placing concrete to insure a firm moist subgrade condition for a least 2 inches below prepared surface.
C. Prepare only a sufficient amount of subgrade in advance of placing of concrete to enable work to proceed smoothly and effectively. Avoid placing of equipment or hauling equipment over completed subgrade until placement of concrete has been completed.
D. The use of sand cushion for subgrade leveling purposes is prohibited.

3.3 INSTALLATION

A. Forms:
1. Set forms accurately to required grades and alignment.
2. Adequately brace to withstand loads applied during concrete placement.
3. Install flexible or curved forms of wood or metal for curves with radius of 300 feet or less.
4. Leave forms in place for a minimum of 12 hours after completion of the finishing operation.

B. Joint Fillers:
1. At driveways to street connections, accurately shape joint filler to concrete section.
2. Securely fasten filler in place and in contact with subgrade for its entire length. Provide holes for dowel bars not more than 1/8" larger than bar diameter.
3. Where joint sealant or sealing compound is scheduled, provide removable tacked-on strips to provide a recess for sealant or compound.

C. Reinforcement:
1. Install reinforcing steel in middle of the pavement thickness.
2. Steel shall be free of rust or mill scale, dirt or oil.

D. Placing and Finishing:
1. Placing: Deposit concrete so that specified thickness will be obtained after vibrating and finishing operations. Minimize handling to prevent segregation. Consolidate concrete by suitable means to prevent formation of voids or honeycombs. Exercise care to prevent disturbance of forms.
2. Finishing: After consolidation and screening, float concrete level to within specified tolerances. Use a straight edge to level and test surface in longitudinal direction to required grade. They shall be troweled and then brushed transversely to obtain a smooth uniform brush finish. Joint and sides shall be edged with suitable tools. Finish edges to provide a smooth dense surface with 2" radius.

3.4 JOINTS

A. Intentional stoppage of concrete placing shall be at planned location of either an expansion joint or construction joint.

B. When stoppage occurs at an expansion joint, install joint assembly as shown on drawings for an expansion joint, with a bulkhead of sufficient section drilled to accommodate required dowels.

C. When stoppage occurs at a construction joint, install joint assembly as detailed on drawings for a construction joint.
1. Provide a bulkhead of sufficient section to prevent deflection, or loss of shape of concrete section. Drill bulkhead to permit continuation of longitudinal reinforcing steel through construction joint.
2. Immediately upon unintended stoppage of concrete placing, place available concrete to a line and install bulkhead perpendicular to surface of pavement and at a required elevation. Place and finish concrete to the bulkhead. Remove and dispose of concrete remaining on subgrade ahead of bulkhead.
3. When placing of concrete is resumed before concrete has set to extent that concrete will stand on removal of bulkhead, new concrete shall be rodded with the first: otherwise, carefully preserve joint face.
4. An edge created by a construction joint of this type shall have a joint steel seal space as detailed on drawings.

D. Provide tooled dummy joints spaced as indicated on the drawings, generally the width of the sidewalk.
1. Tool joints after completion of finishing operations as soon as concrete has hardened to extent necessary to prevent raveling of joint or damaged to adjacent concrete surfaces.
2. Joints shall be continuous across the slab.

E. Expansion joints or isolation joints shall be used to isolate fixed objects abutting or within the paved area. They shall contain pre-molded joint filler for the full depth of the slab and shall be sealed prior
to opening to traffic. Expansion joints for sidewalks and driveways shall be formed, using
expansion joint material of an approved type and shaped to the section. Expansion joints shall be
placed in the sidewalks at 40 foot (12M) intervals, unless otherwise shown on the drawings.
F. Where a driveway approach is to be constructed at a location where there exists a separate curb
and gutter, said curb and gutter shall be removed for the full width of the gutter to the nearest joint
of to a sawed point at the point of radius. On concrete pavement with monolithic curb, the breakout
line shall be 12 inches from the face of the curb line and shall be parallel to it and form a right angle
with the concrete surface. The breakout line shall be a sawed groove.

3.5 CURING
A. Apply membrane curing compound at a uniform rate of approximately 200 sq. ft. per gallon, or as
recommended by manufacturer, as soon as finishing operation has been completed and concrete
has lost its water sheen.
B. At contractor’s option, curing sheets may be used, held in place with moist sand.
C. Curing procedure shall protect concrete, including concrete edges and curbs, against loss of
moisture and rapid temperature change for a period of not less than 4 days from beginning of curing
operation, without damage or making of finished concrete surface.
D. Do not allow pedestrians on concrete for a minimum period of 4 days after placing.

3.6 COLD WEATHER PROTECTION
A. When concrete is placed in cold weather and the temperature may be expected to drop below 35°F,
provide cold weather protection in accordance with ACI 306.
B. When ambient temperature is expected to fall below 32°F during day or night, cover concrete with
protective material to a sufficient depth to prevent freezing of concrete.
C. Protect concrete from freezing temperature for a minimum of 5 days after placing.
D. Remove and replace concrete damaged by frost action.

3.7 SEALING JOINTS
A. Cleaning joints: Prior to applying joint sealing compound, clean joints with compressed air to
obtain a clean and dry surface on face of joints so that sealing material will adhere.
B. Installation:
1. Melt joint sealing compound to proper consistency for pouring using continuous agitator type
kettle with calibrator thermometer. Do not heat above 450°F.
2. Continuously apply joint sealing compound full depth of joint recesses and flush with concrete
surface, in accordance with manufacturers directions. Do not apply when ambient
temperature is below 35°F.

3.8 FIELD QUALITY CONTROL
A. Inspection and testing as specified in Section 01410.

END OF SECTION
SECTION 331100
WATER CONDUIT INSTALLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES:
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
1. Furnishing of all labor, tools, materials, equipment and incidentals required to complete the work.
2. Layout of the work.
3. Installation of water mains, fire hydrants, appurtenances, corrosion protection; and connection to existing system.
4. Sterilization
5. Testing
6. Clean up

1.2 RELATED SECTIONS:
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the Work of other Sections. Other Sections containing related work include but are not limited to the following:
1. Excavation and Backfill for Conduits - Section 3123 34

1.3 REFERENCES:
Meet requirements and recommendations of applicable portions of the Standard listed.

A. American Society for Testing and Materials.
1. ASTM D1784 - Rigid Poly (Vinyl Chloride) (PVC) compounds and Chlorinated Poly (Vinyl Chloride) (PVC) Compounds.
2. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
3. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR series).

B. American Water Works Association (AWWA):
1. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.
2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, 3 Inches through 48 inches, for Water and Other Liquids.
3. AWWA C151 - Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
4. AWWA C153 - Ductile Iron Compact Fittings, 3 inches through 16 inches, for Water and Other Liquids.
5. AWWA C502 - Dry-Barrel Fire Hydrants.
6. AWWA C509 - Resilient Seated Gate Valves, for Water and Sewerage Systems.
7. AWWA C550 - Protective Epoxy Interior Coatings for Valves and Hydrants.

1. Chapter 290.41 Water Sources.
2. Chapter 290.44 Water Distribution

D. Texas Department of Public Transportation Standard Specifications for Construction of
2.1 DUCTILE-IRON PRESSURE PIPE AND FITTINGS:

A. General. Ductile-iron pressure pipe 3" in diameter and larger shall conform to the current American National Standard for Ductile-Iron Pipe Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids, AWWA Standard C151 (ANSI A21.51).

B. Design Requirements. The ductile-iron shall conform in all respects to the specifications for Ductile Iron Castings, ASTM Designation A 536, except the grade shall be as follows unless specified otherwise in the special provisions or in the plans:

C. Pipe class shall be as shown on the plans. 6" through 12" shall be thickness Class 50. For larger diameters or deeper cover, special design shall be provided.

D. Joints. All ductile-iron pressure pipe shall be furnished with one of the following types of joints and as described in the proposal or bid request:

<table>
<thead>
<tr>
<th>Type</th>
<th>Joint</th>
<th>AWWA Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push-on</td>
<td></td>
<td>AWWA C111</td>
</tr>
<tr>
<td>Mechanical Joint</td>
<td></td>
<td>AWWA C111</td>
</tr>
<tr>
<td>Flanged Ends</td>
<td></td>
<td>AWWA C110</td>
</tr>
</tbody>
</table>

Bolts and nuts for mechanical joints or flanged ends (if used underground) shall be of a high-strength low-alloy corrosion-resistant steel and shall conform to High Strength Bolts for Standard Steel Joints, ASTM Designation A 325 (Type 3). All screwed flanges shall be ductile iron.

E. Coating and Lining. All ductile-iron pipe shall be cement-mortar lined inside in accordance with AWWA Standard C104 (ANSI A21.4).

F. Fittings. Fittings shall be of ductile iron and shall conform to the current American National Standard for Gray-Iron and Ductile-Iron Fittings, 3 In. through 48 In., for water and Other Liquids, AWWA Standard C110 (ANSI A21.10) or American National Standard for Ductile Iron Compact Fittings, 3 In. through 12 In. for Water and Other Liquids, AWWA Standard C153 (ANSI A21.53), unless otherwise specified in the proposal, special specification or in the plans. All Fittings shall be rated for a minimum of 250 psi working pressure.

G. Wrapping. Buried pipe and fittings shall be wrapped with 8 mil. polyethylene encasement, AWWA C105.

H. Underwriter's Approval. Ductile-iron pipe shall be approved by the Underwriters' Laboratories, Inc., and shall be accepted by the State Fire Insurance Commission for use in water distribution systems without penalty. All pipe and fittings shall be new.

I. Tests. All ductile-iron pipe and fittings shall be tested in accordance with the applicable provisions of the specifications relating thereto and the class, weight, and casting period shall be shown on each pipe.

J. Rejection. Ductile-iron and fittings may be rejected for failure to meet all of the requirements of this specification.
2.2 POLYVINYL CHLORIDE (PVC) WATER PIPES:

A. General.
Un-plasticized polyvinyl chloride (PVC) water pipe shall meet the requirements of AWWA Standard for Polyvinyl Chloride Pressure Pipe, 4 in. through 12 in., for Water AWWA Standard C900, with cast-iron outside dimensions. Laying lengths shall be 20' ± 1".

B. Thickness Class.
PVC water pipe shall meet the dimension ratios (DR’s) and physical dimensions as shown in the following table. The pressure classification refers to the maximum hydrostatic pressure to which the pipe shall be subject in normal operations.

**PVC WATER PIPE DIMENSIONS**

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>O.D.*</th>
<th>Class 200 (SDR14) Min. Wall Thickness</th>
<th>Class 150 (SDR18) Min. Wall Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Inches</td>
<td>Inches</td>
<td>Inches</td>
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<td>.733</td>
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</table>

*Cast iron pipe O.D. dimensions

C. For sizes 3/4 in. thru 2½ in., pipe shall conform to ASTM D 2411, class 200, solvent weld. Solvent welded sockets shall be schedule 40.

D. Joints.
PVC water pipe shall be furnished with gasketed joints. Lubricant used for pipe and fittings assembly shall be nontoxic and shall have no detrimental effect to either gasket or pipe.

E. Fittings.
Fittings for PVC water pipe shall conform to American National Standard for Gray-Iron and Ductile-Iron Fittings, 3 in. through 48 in., For Water and Other Liquids, AWWA Standard C110 (ANSI A21.10), unless otherwise specified in the proposal, special specifications or on the other plans.

Fittings joints shall be mechanical joints. Bolts and nuts for mechanical joints shall be of high-strength, corrosion-resistant, low-alloy steel and shall conform to ASTM Designation A 325 (Type 3).

F. Approvals.
PVC water pipe shall be approved by the Underwriters’ Laboratories and shall be accepted by the State Fire Insurance Commission for use in water distribution systems in cities and towns of Texas. PVC water pipe shall also bear the seal of approval (or "NSF" mark) of the National Sanitation Foundation testing Laboratory for potable water pipe.

G. Rejection.
PVC water pipe may be rejected for failure to meet all of the requirements of this specification.

H. Copper Tubing.
Copper tubing shall conform to ASTM B88 Type L, drawn and tempered.
I. Solvent Cement.
Solvent Cement shall conform to ASTM D2564 for PVC pipe and fittings.

J. Valves. (For sizes 3/4 in. thru 2½ in.)
1. Acceptable Manufacturers.
   a. Rain Bird Sprinkler Mfg. Corp
   b. The Toro Company
   c. Spears (Ball Valves)
   d. Wilkins (Backflow Preventers)

2.3 GATE VALVES:
A. General. All gate valves 3" through (121.9cm) shall conform to the AWWA Standard for Gate Valves--3 In. through 48 In. NPS--for Water and Sewage Systems, AWWA Standard C509. All gate valves shall be iron body, bronze mounted, double disc, parallel seat, non-rising stem, internal wedging type. Valves must embody the best workmanship and finish. Valve design shall effect minimum torque designs effectively reducing friction and drag through thrust collar design and trackage for gates.

2.4 VALVE BOXES:
Shall be constructed of cast iron and shall be a two piece adjustable sliding type. The cover shall have "W" or "water" cast in the top. Valve boxes shall be the standard catalog products of a reputable manufacturer.

2.5 FIRE HYDRANTS:
A. General: Fire shall conform to the City of Richardson standard details and specifications.

2.6 DETECTOR TAPE FOR UNDERGROUND FIRE PROTECTION PIPING
A. Detector tape for identification of on-site fire protection main locations shall be manufactured by Allen Systems, Inc., Wheaton, IL 60187, or approved equal. Detector tape shall consist of a solid aluminum foil core running in the full length and width of the tape and encased in a protective, high visibility, color-coded inert plastic jacket. The detector tape shall conform to the following:
   1. Plastic jacket shall be impervious to alkalis, acids, and other chemicals in the soil.
   2. Foil core shall have a minimum thickness of 0.35mils.
   3. Overall thickness of the tape shall be 5.5mils, minimum.
   4. Tensile strength shall be 5,000psi, minimum.
   5. Tape width shall be three(3) inch, minimum.
   6. Color of tape shall be “Safety Precaution Blue”
   7. Tape above fire protection system piping shall be read “Caution Buried Fire Protection System Water Line Below”

B. Installation of tape shall be twenty-four(24) inches above the pipe.

2.7 CONCRETE FOR THRUST BLOCKING:
A. Concrete shall be in accordance with Section 03 30 00 “Cast-in-Place Concrete”, compressive strength 2500 psi at 28 days.

PART 3 - EXECUTION

3.1 EARTHWORK: Refer to Section 31 20 00

3.2 BEDDING: Pipe shall be bedded as shown on the plans.
3.3 EXCAVATION AND BACKFILL FOR CONDUITS: Refer to Section 31 23 34

A. General.

1. Pipe Handling: All pipe, fittings and specials shall be handled in such a manner as not to damage the material. All dirt and trash shall be removed from the pipe prior to installation. No hooks shall be permitted. When it becomes necessary to deflect the pipe to avoid obstructions, the deflection of each joint must be within the limits provided by the manufacturer. The pipe is to be kept clean during the laying operation and free of all dirt and trash. At the close of each operating day, the open end of the pipe is to be effectively sealed against the entrance of all objects and especially water.

2. Stringing of Pipe: Stringing of pipe in advance of the laying operation shall be restricted to one week’s laying and shall be done in such a manner as to create no hazard to nor interference with traffic. Ready access shall be provided to all streets, alleys and driveways. The pipe shall be protected with barricades and warning signs at all times. Any damage to the pipe shall be corrected at the expense of the Contractor.

3. Laying Underground Conduit Pipe: Previous to being lowered into the trench, each pipe shall be carefully inspected; and those not meeting specifications shall be rejected and either destroyed or removed from the job. All lumps or excrescences on the ends of conduit shall be removed before it is lowered into the trench. The pipe and specials shall be so laid in the trench that after the project is completed the interior surface shall conform accurately to the grade and alignment indicated on the plans. Bell holes shall be excavated and all pipe shall be carefully adjusted to fit snugly in cradling or bedding so that the entire length bears on cradling or bedding material with no wedging or blocking to hold up the bell. All pipe shall be laid in the dry, regardless of the type of joint used. Pipes shall be laid with the bell or groove end upgrade unless otherwise approved by the engineer and shall be laid with the bell or collar away from the last section placed. Before laying the pipe, the interior of the joints shall be carefully bored smooth and clean and the annular space shall be kept free from dirt, stones or water. Pipe shall be installed and joints made up in complete conformance with the instructions and recommendations regarding proper installation and assembly furnished by the manufacturer. Proper facilities shall be provided for hoisting and lowering the section of the pipe into the trench without disturbing the prepared foundation and the sides of the trench. All pipe shall be so laid that the contact in the joint between two lengths of pipe shall be uniform throughout the circumference of the joint. Where curves in the alignment are indicated on the drawings, standard pipe (short sections of pipe or bevels) shall be used with the outside edge of the joint pulled away from the seat to make a smooth curve. When work is suspended on the line for any reason, the end of the line shall be properly closed with an effective watertight seal or plug manufactured for this purpose.

4. Existing Utilities. Pipe capable of supporting its weight approximately at right angles to the ditch shall not require additional support, unless shown on the plans, other than the exercise of care in placing new conduit under same and in placing backfill, except when the span is excessive. Existing utilities shall be replaced with cast iron or any suitable piping to convey the contents, supported with concrete or a concrete utility support per details on the plans. After the new utility is laid, the backfill to the base of the concrete support shall be stabilized by the use of cement-stabilized soil. Pipes parallel to and in the edge of cut, shall be supported or rerouted if so indicated on the plans. Utilities parallel to and in edge of cut shall be adequately protected without additional compensation except as set out in the contract and proposal.

3.4 WATER MAIN INSTALLATION:
A. Description. This work shall include the installation and construction, complete in place, of pipe conduits and fittings as specified herein and in conformity with the lines, grades, dimensions, materials and designs shown on the plans.

B. Materials: The pipe shall be of the kind and strength shown on the plans and provided in the proposal and contract. Materials for corrosion protection of water conduits and appurtenances shall be of the type as may be called for on the plans or in the special specifications. Any pipe, fitting, solder or flux which is used in the installation or repair of any public water system must be lead-free. For purposes of this section, “lead-free” means solders and flux containing not more than 0.2 percent lead, and pipes and pipe fittings containing not more than 8.0 percent lead.

C. Laying Water Conduit: All pipe shall be so laid that the contact in the joint between two lengths of pipe shall be uniform throughout the circumference of the joint. Where curves in the alignment are indicated on the drawings, and the curves are flat, standard pipe shall be used with the outside edge of the joint pulled away from the seat to make a smooth curve. Deflection of the joint to form curves shall not exceed the limits of Table 2, AWWA C-600. Where curves are sharp, short sections of pipe, bevels or bends shall be used and blocked. When pipe is cut by the Contractor to insert a valve or fitting, the bell and remaining section may be laid beyond the valve or fitting.

D. Pipe Joints: All joints in pipe conduits shall be thoroughly cleaned at the time the joint is made.

E. Rubber Gasket Joints: Rubber gaskets shall conform to the applicable specifications under which the pipe is supplied. Loose gaskets shall be protected from sunlight, contamination and contact with gasoline or fuels.

Rubber gasket joints for water mains consist of our general types:
1. Push-on type used for gray or ductile iron, steel and plastic pipe.
2. Mechanical type used for gray or ductile iron and fittings for asbestos-cement pipe.
3. Rubber and steel joint ring type used for steel cylinder type, reinforced concrete pipe.
4. Double rubber gasket couplings used for pressure pipe. Each type, except mechanical, requires the use of a lubricant to facilitate assembly. The lubricant shall be nontoxic, shall not support the growth of bacteria and shall have no deteriorating effects on the gasket. The lubricant shall not impart taste or odor. Care should be taken not to over-use the lubricant since it would then require excess effort to disinfect.

3.5 FIRE HYDRANTS INSTALLATION:
A. General. Fire hydrants shall be installed as shown on the appurtenance sheets or as directed by the Owner.

B. Installation. The hydrant shall set truly vertical and be securely braced and blocked on well-compacted or undisturbed soil surrounded by clean gravel or stone (min. of 7 CF) to permit free draining of the hydrant, with the large steam nozzle facing the nearest curb.

3.6 PURGING AND STERILIZATION OF WATER MAINS:
A. General. Before any newly constructed water main shall be permitted to be placed into service, it shall be purged and tested; or purged, sterilized and tested until the bacterial count within the main meets the Texas Natural Resource Conservation Commission standards.

B. Procedure. When the entire pipeline or selected sections have been completed, the line or section shall be disinfected according to the following procedures:
1. Pre-sterilization. For convenience in certain locations chlorinated lime (HTH) be placed in the pipe as laid.

2. Sterilization: Sterilization of the main shall be accomplished by the "continuous feed" method or the "slug" method described as follows: The free chlorine amounts shown are minimum. Higher rates may be required by the Engineer. Calcium hypochlorite granules shall be used as the source of chlorine.

3. Continuous Feed Method. If the "continuous feed" method of chlorination is used, the following steps shall be taken:
   a) Water from the existing distribution system or other approved source of supply shall be made to flow at a constant rate in the newly laid main.
   b) At a point not more than 10 feet downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine. Chlorine application shall not cease until the entire main is filled with heavily chlorinated water.
   c) The chlorinated water shall be retained in the main for at least 24 hours, during which time all valves and hydrants in the section treated shall be operated in order to disinfect the appurtenances. Every effort shall be made to prevent the flow of chlorinated water into mains in active service. At the end of the 24 hour period, the treated water in all portions of the main shall have a residual of at least 10 mg/l free chlorine.
   d) The heavily chlorinated water shall then be flushed from the main and disposed of in a non-objectionable manner.

4. Slug Method. If the "slug" method of chlorination is used, the following steps shall be taken:
   a) Water from the existing distribution system or other approved source of supply shall be made to flow at a constant rate in the newly laid main.
   b) At a point not more than 10 feet downstream from the beginning of the new main, water entering the main shall receive a dose of chlorine such that the water shall have not less than 100 mg/l free chlorine. The chlorine shall be applied continuously and for a sufficient time to develop a solid column or "slug" of chlorinated water that shall expose all interior surfaces to the "slug" for at least three hours.
   c) As the chlorinated water flows past the fittings and valves, they shall be operated so as to disinfect the appurtenances. Every effort shall be made to prevent the flow of chlorinated water into mains in active service.
   d) The heavily chlorinated water shall then be flushed from the main and disposed of in a non-objectionable manner.
   e) Contractor Requirements. The Contractor shall be required, as a minimum, to prepare the main for sterilization and secure same after chlorination is complete. This should include the following:
   f) In general, this shall consist of furnishing all equipment material and labor to satisfactorily prepare the main for the sterilization method selected. The Contractor shall also be required to provide adequate provisions for sampling.
   g) Unless otherwise specified in the special contract documents, the Contractor shall make all necessary taps into the pipe to accomplish chlorination of the new line.
   h) After satisfactory completion of the sterilization operation, the Contractor shall remove surplus pipe at the chlorination and sampling points, plug the remaining pipe, backfill and complete all appurtenances work necessary to secure the main. Water samples from a suitable tap (not through a fire hydrant) for analysis by the Owner's laboratory, unless otherwise specified in the special provisions or in the plans shall be taken. If the tests show satisfactory quality of water, the line may be placed in service. Unsatisfactory
test results shall require a repeat of the disinfection process through retests. The process shall not terminate until a satisfactory sample is obtained.

C. Hydrostatic Test:
   1. General:
      a. After pipe has been laid and initial backfill and blocking completed, and while joints and fittings are still exposed, test water lines hydrostatically to a test pressure of 150 psi. Achieve test pressure with compressed air.
      b. Provide connections, pumps, gauges, meters and other equipment necessary for performance of tests.
   2. Procedures:
      a. Before applying specified pressure test, expel all air from the pipe by slowly filling each valved section of pipe with water. Provide taps necessary to expel trapped air.
      b. Examine all piping, fittings, valves and joints during testing. Fully operate each valve in the test section during testing.
      c. Test each section for a minimum of 2 hours when joints are exposed, 8 hours when joints are covered.
      d. Test pipe lines in length between valves or plugs of not more than 1000 feet.
   3. Maximum Allowable Leakage: Not exceed 12 gallons per inch of pipe diameter per mile of pipe per 24 hours, except replace joints regardless of total leakage quantity where visible leaks occur at exposed joints and where leaks are evident at the surface of joints that are covered.
   4. Replace defective material with sound material, and repeat test procedures until approved is obtained.

3.7 CLEAN UP:
Upon the completion of the work covered in this Section, the Contractor shall clean up all work areas by removing all debris, surplus material, and equipment from the site. The ground surface shall be restored to its original condition as nearly as possible.

END OF SECTION
SECTION 333100
SANITARY SEWER LINE INSTALLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES:
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
   1. Furnishing of all labor, tools, equipment and incidentals to complete the work.
   2. Layout of the work.
   3. Fabrications, construction and installation of sanitary sewer pipe, laterals, manholes, cleanouts and fittings.
   4. Testing of completed sanitary sewer line, complete in place with laterals, manholes, cleanouts and fittings.
   5. Clean up.

1.2 RELATED SECTIONS:
A. Coordinate the work of this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the Work of other Sections. Other Sections containing related work include but are not limited to the following:
   1. Excavation and Backfill for Conduits - Section 3123 34
   2. Cast in Place Concrete - Section 0330 00

1.3 REFERENCES:
Meet requirements and recommendations of applicable portions of the Standard listed.
A. ASTM A48 - Gray Iron Castings.
B. ASTM C144 - Aggregate for Masonry Mortar.
C. ASTM C270 - Mortar for Unit Masonry.
D. ASTM C478 - Precast Reinforced Concrete Manhole Sections.
E. ASTM D1248 - Polyethylene Plastics Molding and Extrusion Materials.
F. ASTM D2241 - Poly Vinyl Chloride (PVC) Pressure Rated Pipe (SDR-Series).
G. ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
I. ASTM F679 - Poly Vinyl Chloride (PVC), Large Diameter Plastic Gravity Sewer Pipe and Fittings.
K. AWWA C210 - Liquid Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines.
M. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges, 2004, TxDOT.

PART 2 - PRODUCTS

2.1 Not Used

2.2 POLYVINYL CHLORIDE (PVC) SEWER PIPE & FITTINGS:
A. General. PVC Sewer Pipe and Fittings shall conform to the current ASTM Designation D 3034, for 4 inch through 15 inch diameter and ASTM designation F 679 for greater than 15
inches diameter. Engineering evaluations of specific installation requirements is recommended.

B. Pipe Sizes:
1. For pipe sizes 4 through 15 inches in diameter. The pipe shall be Type PSM SDR-35 or SDR-26 as specified in ASTM Designation D 3034.
2. For pipe sizes greater than 15 inch diameter. The pipe shall be Type T-1 and T-2B as specified in ASTM Designation F 679.

C. Material. The pipe shall be made of PVC plastic having cell classification of 12454-B, 12454-C or 12364-C and fittings shall be made of PVC plastic having cell classifications of 12454-B, 12454-C or 13343-C as defined in ASTM Designation D 1784.

D. Installation. Pipe produced to this specification shall be installed in accordance with ASTM Designation D 2321. The internal diameter of the installed barrels of the pipe must not be reduced by more than 5% of its base inside diameter when measured not less than 30 days following completion of installation.

E. Testing. All pipes shall meet ASTM requirements for flattening, impact resistance, stiffness, joint tightness and extrusion quality as specified in ASTM Designation D 3034 and F 679.

2.3 PRECAST REINFORCED MANHOLE SECTIONS:
A. General: These specifications cover precast reinforced concrete manhole section conforming to precast reinforced concrete manhole sections, ASTM Designation C 478 (C 478M), with the following additions:
1. All pipes shall be machine made by process which shall provide for uniform placement of zero slump concrete in the form and compaction by mechanical devices which shall assure a dense concrete in the finished product, except that reducer cones may be wet-cast.
2. Aggregate for the concrete shall comply with requirements of the current Concrete Aggregates, ASTM Designation C33, with the additional requirement that the aggregate shall have a minimum of 50 percent of calcium carbonate equivalent.
3. Minimum wall thickness for the manhole risers shall be as listed under Wall "B" in the "Class Tables" of ASTM Designation C76 (C76M).
4. Unless otherwise noted, manhole steps shall be furnished. If required, the steps shall be of the plastic or rubber coated steel type, with a clear cleat space of 10 in. (25.4 cm) minimum that shall support a concentrated load of 300 pounds (136.2 kg).
5. Resilient connectors between reinforced concrete manhole structures and pipes shall meet the requirements of ASTM Designation C 923 or ASTM C 443. The resilient connector shall provide an airtight seal with eliminates infiltration and exfiltration.

B. Joints: Joints shall conform to the joint specification ASTM Designation C 478 (C 478M).

C. Coatings and lining: Coatings and liners called for in the specifications or indicated on the plans shall meet the requirements for Item 2.12.19. and shall be installed or applied by the manufacturer.

D. Lifting devices: Manhole sections and cones may be furnished with lift lugs or lift holes. If lift lugs are provided, they shall be 180 degrees apart. Cast-in-place nuts must have clean threads capable of inserting lugs bolts. The lift lug design must be approved by the engineer. If lift holes are provided, they shall be plugged with a nonmetallic nonshrink grout approved by the engineer. Field repairs shall not be allowed.

E. Rejection: Manhole sections shall be subject to rejection on account of failure to conform
to any of the requirements specified herein or have defects as follows:

1. Variations in any dimensions exceeding the permissible variation prescribed.
2. A piece broken out of the bell or spigot or tongue or groove in such size that the water tightness of the joint should be impaired.
3. Any shattering or flaking of concrete or other conditions indicating an improper concrete mix.
4. Lack of uniformity in placement steel which might preclude all joints being typical of those tested.
5. Cracks sufficient to impair the strength, durability or serviceability of the pipe.
6. Joint sections with spalls, cracks, fractures, or other imperfections that could adversely affect the performance of the joint.

2.4 PREFORMED FLEXIBLE JOINT SEALANT:

A. General: This specification covers a cold-applied preformed flexible butyl rubber or plastic sealing compound for sealing interior and/or exterior space on concrete sewer pipe and manhole sections, where infiltration or exfiltration is a factor in the design.

B. Applicable standards: Except as modified or supplemented herein, all preformed flexible joint sealants shall conform to the applicable requirements of the following standard specifications, latest edition:

<table>
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<th>Standard</th>
<th>Title</th>
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<tr>
<td>SS - S - 210A</td>
<td>Federal Specification</td>
</tr>
<tr>
<td>M198</td>
<td>American Association for State Highway and Transportation Officials (AASHTO)</td>
</tr>
</tbody>
</table>

C. Basis of acceptance: The acceptability of the preformed flexible joint sealant shall be determined by the results of physical tests, by inspection and by approval of its experience record.

D. Material: The joint sealer shall be supplied in either extruded rope-form of suitable cross-sectional area or flat-tape form and shall be sized as recommended by the manufacturer and approved by the engineer. The joint sealer shall be protected by a suitable removable wrapper. The joint sealer shall not in any way depend on oxidation, evaporation, or any other chemical action for either its adhesive properties or cohesive strength. The joint sealer shall remain totally flexible without shrinking, hardening, or oxidizing regardless of the length of time it is exposed to the elements. The manufacturer shall furnish an affidavit attesting to the successful use of the product as a preformed flexible joint sealant on concrete pipe and manhole sections for a period of at least five years.

E. Installation of joint sealant: All surfaces to be in contact with the joint sealant shall be thoroughly cleaned of dirt, sand, mud or other foreign matter. A primer shall be applied to all surfaces prior to installing the joint sealant in accordance with recommendations by the manufacturer. The protective paper wrapper shall remain on the joint sealant until immediately prior to placement of the pipe in the trench. After removal of the protective paper wrapper, the joint sealant shall be kept clean. Backfilling of pipe laid with this joint sealer may proceed after the joint has been inspected by the engineer.

F. Compliance with specifications: If requested by the engineer, the contractor shall provide results of above specified tests to insure product compliance with these specifications or shall supply an affidavit of compliance from the manufacturer insuring compliance with these specifications.

G. Rejection: The preformed flexible joint sealant may be rejected for failure to meet any of the requirements of this specification.
2.5 CASTINGS:
A. General. Steel and iron castings shall meet the requirements specified herein and on the plans and contract documents.

B. Steel Castings.
1. High-Strength Steel Castings. High-strength steel castings shall meet the requirements of High-Strength Steel Castings for Structural Purposes, ASTM A 148, Grade as specified.
2. Mid Steel Castings. Mild steel castings shall meet the requirements of High-Strength Steel Castings for Structural Purposes, ASTM A 14, Grade as specified.

C. Iron Castings.
1. Material. Casting shall conform to the following ASTM Designations as applicable.

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<tr>
<th>MATERIAL</th>
<th>ASTM</th>
<th>GRADE</th>
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<tr>
<td>Gray Iron Castings</td>
<td>A 48</td>
<td>Class 25 Minimum</td>
</tr>
<tr>
<td>Gray Iron Castings for Valves,</td>
<td>A126</td>
<td>Class B</td>
</tr>
<tr>
<td>Flanges, and Pipe Fittings</td>
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</table>

2. Workmanship. All casting shall be true to pattern in form and dimension, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting strength and value for the service intended. Angles shall be filleted, and arises shall be sharp and true.

3. Coatings. Castings shall be coated with hot or cold applied tar as appropriate.

4. Rockers and Bearing Plates. Rockers and bearing plates shall be cast iron of the type and grade indicated on the plans and contract documents.

D. Rejection. Any metal or material specified in this section may be rejected for failure to meet all of the provisions of this specification or for any defect causing said metal or material to be unusable for its intended use.

PART 3 - EXECUTION

3.1 GENERAL:
A. Pipe Handling. All pipe, fittings and specials shall be handled in such a manner as not to damage the material. All dirt and trash shall be removed from the pipe prior to installation. Hooks shall not be permitted. When it becomes necessary to deflect the pipe to avoid obstructions, the deflection of each joint must be within the limits provided by the manufacturer.

B. Stringing of Pipe. Stringing of pipe in advance of the laying operation shall be restricted to one day laying and shall be done in such a manner as to create no hazard or interference with traffic. Ready access shall be provided to all streets, alleys and driveways. The pipe shall be protected with barricades and warning signs at all times. Any damage to the pipe shall be corrected at the expense of the contractor.
C. Laying Underground Conduit Pipe. Previous to being lowered into the trench, each pipe shall be carefully inspected; and those not meeting specifications shall be rejected and either destroyed or removed from the job. All lumps on the ends of conduit shall be removed before it is lowered into the trench. The pipe and specials shall be so laid in the trench that after the project is completed the interior surface shall conform accurately to the grade and alignment indicated on the plans. Bell holes shall be excavated and all pipe shall be carefully adjusted to fit snugly in cradling or bedding so that the entire length bears on cradling or bedding material with no wedging or blocking to hold up the bell. All pipe shall be laid in the dry, regardless of the type of joint used.

Pipes shall be laid with the bell or groove end upgrade and shall be laid with the bell or collar away from the last section placed.

Before laying the pipe, the interior of the joints shall be carefully bored smooth and clean and the annular space shall be kept free from dirt, stones or water. Pipe shall be installed and joints made up in complete conformance with the instructions and recommendations regarding proper installation and assembly furnished by the manufacturer. Proper facilities shall be provided for hoisting and lowering the section of the pipe into the trench without disturbing the prepared foundation and the sides of the trench. All pipe shall be so laid that the contract in the joint between two lengths of pipe shall be uniform throughout the circumference of the joint. Where curves in the alignment are indicated on the drawings, standard pipe (short sections of pipe or bevels) shall be used with the outside edge of the joint pulled away from the seat to make a smooth curve.

When work is suspended on the line for any reason, the end of the line shall be properly closed with an effective watertight seal or plug manufactured for this purpose.

D. Existing Utilities. Pipe capable of supporting its weight approximately at right angles to the ditch shall not require additional support, other than the exercise of care in placing new conduit under same and in placing backfill, except when the span is excessive.

Pipes parallel to and in the edge of cut, shall be supported or rerouted if so indicated on the plans. Utilities parallel to and in edge of cut shall be adequately protected without additional compensation except as set fourth in the contract and proposal.

3.2 INSTALLATION:
A. Sewer Lateral Connections. Sewer lateral lines shall be constructed as required and shown on the plans.

B. Sanitary Sewer Joints. When specified in the special provisions or in the plans, a test tee shall be installed at the end of the service line, with the branch in a vertical position.
1. Rubber Gasket Joints. Rubber gaskets shall conform to applicable specifications under which the pipe is supplied. Loose gaskets shall be protected from sunlight, contamination and contact with gasoline or fuels. On pipe for which the gasket is not fixed in place by the manufacturer, the bell-and-spigot or tongue-and-groove shall be thoroughly cleaned by wire brushing and wiping until clean and dry. On pipe which does not require the rubber gasket to be cemented in place, the rubber gasket shall be placed in position on the spigot ring just prior to laying the pipe. The lower edge of the gasket shall be placed under the spigot in the seat and stretched evenly upward on each side to fit over the top of the spigot; and the rubber gasket shall fit snugly and not have uneven tensile stresses. After checking to be sure that the bell-and-spigot are thoroughly clean, the inside surface of the bell shall be lubricated with a suitable solution (flax soap) to facilitate the telescoping of the joint. Petroleum lubrication shall not be permitted. The spigot end of the pipe shall be entered into the
bell of the adjoining pipe and forced into position. Exceptional care shall be taken in making the field joint. Bumping of the pipe shall not be permitted. On small pipe, if the bottom of the trench is firm enough, a bar having a blade on the end may be pushed into the ground, then the bar may be used as a level to push the pipe home. However, if trench conditions are too unstable, or are in rock, it shall be necessary to use mechanical means to bring the pipe together positively. Each joint shall be partially backfilled or suitably blocked to prevent creeping. Unless otherwise specified in the special provisions or in the plans, for all sizes of concrete pipe larger than 24 inches (6M) in diameter, the inside annular space provided for that purpose shall be completely filled with a plastic portland cement mortar (composed of 1 part cement to 2 1/2 parts sand); or preformed flexible joint sealant in rope form; or troweling type. Where the pipe has been corrosion protected, and an annular space is open, only the bottom half of the inside annular space shall be filled with mortar; and a ready-mix cold-pour compound shall be used in the upper half, as hereinbefore described, that is resistant to acid, alkalis, and gases and is compatible with rubber. The joint shall be finished smoothly and all surface materials removed.

2. Chemically Welded Joints. The joint materials shall conform to the applicable specifications under which the pipe is supplied. The joint shall be installed per recommendations of the manufacturer. The ditch embedment should be to grade, with the advance bell hole scooped out prior to laying so that the pipe shall be to grade as the joint is made.

3. Compression Joints. The joint materials shall conform to the applicable specifications under which the pipe is supplied. The bells and spigots must be thoroughly clean. Extreme care must be exercised to prevent damage to the joint. The spigot end shall be inserted into the bell and pushed home after a suitable lubricant, as recommended by the pipe manufacturer, is applied. Petroleum lubrication shall not be permitted. The ditch embedment should be to grade, with the advance bell hole scooped out prior to laying so that the pipe should be to grade as the joint is made.

3.3 TESTING AND INSPECTION:

In order to ascertain that the main shall perform the function for which it was designed and constructed, performance tests shall be routinely executed. Tests can be made by one of two methods. Infiltration or exfiltration tests may be made on sections as they are completed to assure that performance is satisfactory. Manholes shall be tested by infiltration or exfiltration. Tunnelled, bored or jacked sections of all pipes shall be tested by exfiltration only. Testing shall be performed by the contractor in the presence of the owner’s representative after all backfilling and compaction are complete. All sections between manholes or between a manhole and a dead end shall be tested separately. In the making of all tests, the contractor shall furnish the required equipment and labor. Tests may be repeated until each sewer individually meets the specifications as to quantity of allowable infiltration or exfiltration as set out below. All testing work shall be included in the bid price.

A. Infiltration Test. The total seepage in infiltration of ground water as determined by test shall in no case exceed 50 gallons per inch of normal diameter of pipe per mile (0.2 cubic meters per centimeter of nominal diameter per kilometer) over a 24-hour period; and shall be the same regardless of piping material used. The allowable leakage of each manhole, or other structure, shall be as specified on the plans. An infiltration test or tests shall be made on all sections of the project where air testing could not be adequately performed and on each manhole individually before placing the system in service and before any connections are made to other sewers. If the quantity of the effluent into the sewer or sewers is in excess of the maximum quantity as hereinafter specified, the joints shall be repaired or the sewer relayered, if necessary, or other remedial construction shall be performed by and at the
expense of the contractor, in order to reduce the quantity of ground water infiltration to an amount within limits as specified. The test shall be made by utilizing ground water, if any, or flooding a section at a time. Observation from jetting is not acceptable.

1. Using Existing High Ground Water. Where the natural ground water, after well points are removed, is above the top of the pipe for a section, the flowing of water in the pipe and the rate of seepage and infiltration for the section so submerged can be measured.

2. Flooding By Sections. Backfill shall be brought up to at least a foot (30cm) over the pipe on the section to be tested. More cover may be required on larger pipes to prevent the pipe from floating out of grade. Dams or dikes are placed tightly around pipe at either end and the ditch filled with water to an average depth of four feet (1.2M) over the pipe. Flow at the lower end is measured for the section so submerged. Dikes shall be placed around each manhole; and the area adjacent to the manhole shall be flooded to the top of the manhole and the flow into the manhole measured.

3. Flushing or Jetting of Backfill. During jetting to settle the backfill, the flow at the lower manhole shall provide a control indication of possible infiltration which should be corrected.

B. Exfiltration. A section of pipe below a manhole is bulkheaded at either end with a 6" (15cm) pipe inserted into lower bulkhead and by use of a 90-degree bend. The 6" (15cm) pipe is set in a vertical position. A 2" (5cm) vent pipe is inserted in lower end and extended upward four feet (1.2M). The 6" (15cm) pipe is filled with water, filling the sewer line until all air is forced out through the vent tube. When the water levels are level in the 2" (.5cm) and 6" (15cm) pipes, the drop in the 6" pipes (15cm) due to exfiltration over a specific time shall be measured and the loss of water due to exfiltration calculated. This amount shall be reduced by 25 percent to obtain equivalent infiltration over a specific time and the loss of water due to exfiltration calculated. Conditions encountered in construction may vary this procedure slightly, but essentially this method shall be used.

3.4 SEWER APPURTENANCES:

A. Description. This section shall govern for the construction of all miscellaneous sanitary sewer structure such as junctions, transitions, special concrete manholes, creek crossings, river crossings, and utility supports; and for the construction of appurtenances such as manholes, cleanouts, deep-cut connections, wyes, stoppers, and bulkheads, fittings and such other miscellaneous structures or appurtenances which may be shown on the plans.

B. Connections of pipe sewer to existing sewers or sewer appurtenances shall be as shown on the plans or as directed by the engineer. Connections shall be made to prevent the occurrence of bi-metallic corrosion or any other corrosion that can result by joining incompatible materials. The bottom of the existing structure shall be mortared or concreted if necessary, to eliminate any drainage pockets by the new connection, and in general accord with details for the new structure as shown on the plans. Where the sewer is connected into old structures which are to remain in service, any damage to the structure resulting from the work of making the connection shall be restored by the contractor to the satisfaction of the engineer.

C. Creek Crossings. Creek crossings using pier construction shall be made in accordance with the details shown on the plans.

D. Laterals. Laterals shall be located as indicated on the plans or as directed by the engineer. Details of construction shall be as shown on the plans. The lateral shall be of the same pipe material as the main.

Laterals to property shall be marked under the ground surface by placing green metallic...
plastic tape with the word "SEWER" printed on the tape at regular intervals. One end of the tape shall be placed at the end of the lateral; the other end shall be just under the ground surface projecting at least one foot (30 cm) back of the proposed or existing curb.

3.5 MANHOLES:
Sanitary sewer manholes shall be fabricated in different configurations to meet with specific needs required in the sanitary sewer system.

A. General. Unless otherwise specified, manholes shall have an inside diameter of four feet (1.2 M). Manholes constructed in advance of paving projects shall be constructed with the top of the concrete portion of the manhole 23 inches below the final finished grade. The ring and cover shall be place on a built-up section of brick and mortar. Manholes shall be watertight. The type and size, if other than four feet inside diameter, shall be shown on the plans for each location.

1. Cast-In-Place. The base, wall and cone shall be Type 1 concrete poured and vibrated to assure a monolithic structure. Construction joints with waterstops must be approved by the engineer.

2. Precast. The base shall be 3600 psi concrete. The precast sections shall be of the bell-and-spigot design incorporating tapped O-ring gaskets, or tongue-and-groove with premolded joint sealing compound. Lift holes may be used but must be filled with nonshrink grout after the section is in place. Combination of joints shall be selected to minimize the number of individual segments. Long joints shall be used in the bottom and shorter segments utilized for top adjustments.

3. Drop. Drop manholes shall be constructed in accordance with details on the plans. The construction is the same as that for a cast-in-place manhole with special provisions incorporated to provide drop piping.

4. Steps, Rings and Covers. Installation of steps, rings and covers shall be shown on the plans. Manhole steps shall only be used if specified on the plans or in the contract document. Where manhole steps are not used, the contractor shall furnish a ladder for access for inspection. Manhole covers shall be detailed on the plans.

B. Special Requirements.

1. Flow Channel. When specified in the special provisions or in the plans, the sanitary sewer pipe shall be laid through the manhole stations were possible, prior to concreting, so that the full depth of the pipe is embedded in concrete to form the flow channel.

(a) Flow Channel Alternate. Where pipe cannot be used through the manhole due to intersecting flow channels, flow channels equivalent to the top of pipe shall be formed with concrete then trowel to a smooth, even finish with a steel trowel.

(b) Manhole Bottom. The manhole bottom from wall line to flow channels shall be sloped and troweled smooth on a grade of one inch per foot (2.5cm per 30cm) with a liberal radius applied at flow channel intercepts.

2. First Full Joint. The first full joint of pipe extending from the manhole shall be cradled in concrete to the pipe joint in the same pour as that for the manhole base slab as shown on the plans.
3. Pick Slots. For all manhole installations in the streets, the manhole covers shall be provided with pick slots in lieu of pick holes. If the rim elevation above surrounding ground is prohibited by land use or other reasons, a cover with a pick slot as described for use in street locations shall be used.

3.6 CLEANOUTS:
A. Construction Methods. Cleanouts shall be constructed in accordance with the plans and these specifications for materials and construction.

END OF SECTION
SECTION 334100
STORM SEWER LINE INSTALLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Work included in this Section, while not all inclusive but listed as a guide, shall include:
   1. Furnishings of all labor, tools, equipment and incidentals to complete work.
   2. Layout of the work.
   3. Installation of atrium drains, culverts, and appurtenances including head walls.
   4. Trench safety.
   5. Testing.
   6. Clean up.

1.2 RELATED SECTIONS
A. Coordinate the work in this Section with the Work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the Work of other Sections. Other Sections containing related work include but are not limited to the following:
   1. Excavation and Backfill for Conduits - Section 31 23 34

1.3 REFERENCES
Meet requirements and recommendations of applicable portions of the Standard listed.
A. ASTM C76 - Reinforced Concrete Storm Drain and Sewer Pipe.
C. ASTM D3350 - Polyethylene Plastics Pipe and Fittings
D. ASTM D1785 - Plastic Pipe, Schedules 40, 80 and 120.
E. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges, 2004 TxDOT.

1.4 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract and Section 01 33 00.
B. Pipe Certifications: Manufacturers certification that pipe or precast units meets the requirement of these specifications.

1.5 PROJECT CONDITIONS
A. Verify that storm sewerage system piping may be installed in compliance with original design and referenced standards.
B. Locate existing storm sewerage piping and structures that are to be abandoned and closed.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS
A. General. Provide pipe and pipe fitting materials compatible with each other and as indicate on the drawings. Where more than one type of materials or product is indicated, selection is installers option.
B. PVC Sewer Pipe and Fittings for sizes 4 thru 15 inches in diameter are SDR26: ASTM D 3034, SDR 35, for solvent cement or elastomeric gasket joints.

C. PVC Sewer Pipe and Fittings for sizes greater than 15 inches in diameter: ASTM F 679, T-1A or T-1B wall thickness, bell and spigot, for elastomeric gasket joints.

D. Reinforced Concrete Sewer Pipe and Fittings: ASTM C 76 of the class shown on the plans.

E. HDEP Storm Sewer Pipe and Fittings: ASTM D 3350

2.2 MANHOLES
A. Precast Concrete Manholes: ASTM C 478, precast reinforced concrete, of depth indicated with provision for rubber gasket joints.
   1. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having a separate base slab or base section with integral floor.
   2. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.
   3. Top Section: Eccentric cone type, unless concentric cone or flat-slab-top type is indicated. Top of cone to match grade rings.
   4. Grade Rings: Provide 2 or 3 reinforced concrete rings, of 6 to 9 inches total thickness and match 24-inch diameter frame and cover.
   5. Gaskets: ASTM C 443, rubber.
   6. Steps: Cast into base, riser, and top sections sidewall at 12 to 16 inch intervals.
   7. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.
   8. Channel and Bench: Concrete.

B. Cast-in-Place Manholes: Reinforced concrete of dimensions and with appurtenances indicated.
   2. Channel and Bench: Concrete.
   3. Steps: Cast into sidewall at 12 to 16-inch intervals.

C. Manholes Steps: Wide enough for an adult to place both feet on one step and designed to prevent lateral slippage off the step. Material shall be steel-reinforced plastic.

D. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, heavy duty, ductile iron, 24-inch inside diameter by 7 to 9-inch riser with 4-inch minimum width flange, and 26-inch diameter cover, indented top design, with lettering STORM SEWER cast into cover.

2.3 CATCH BASINS
A. Precast Concrete Catch Basins: ASTM C 478 or ASTM C 858, precast reinforced concrete, of depth indicated. Sections shall have provisions for rubber gasket joints. Base section slab shall have minimum thickness of 6 inches, riser sections shall have minimum thickness of 4 inches and be 48 inches inside diameter, and top section and grade rings shall match 24-inch frame and grate, unless otherwise indicated.
   1. Base Section: Base riser section and separate and base slab, or base riser section with integral floor.
   2. Riser Sections: Sections shall be of lengths to provide depth indicated.
   3. Top Section: Flat slab type with opening to match grade rings.
   4. Grade Rings: Provide 2 or 3 reinforced concrete rings, of 6 to 9 inches total thickness.
   5. Gaskets: ASTM C 443, rubber.
6. Step: Cast into riser sidewall at 12 to 16-inc intervals.
7. Pipe connectors: ASTM C923, resilient, of size required, for each pipe connecting to base section.
8. Channel and Bench: Concrete.

B. Cast-in-Place Catch Basins: Reinforced concrete of dimensions and with appurtenances indicated.
   2. Channel and Bench: Concrete.

C. Curb Inlets: Precast concrete, brick or other materials, of dimensions conforming to the plans.

2.4 JOINTING MATERIALS
Unless otherwise specified on the plans the Contractor shall have the option of making the joints using any of the materials described herein. For all jointing materials except mortar, the Contractor shall furnish by the Manufacturer’s Certificate of Compliance.

A. Mortar: Mortar shall consist of one (1) part cement, two (2) parts sand and sufficient water to make a plastic mix.

B. Cold Applied, Plastic Asphalt Sewer Joint Compound. This material shall consist of natural and/or processed asphalt base, suitable volatile solvents and inert filler. The consistency is to be such that the ends of the pipe can be coated with a layer of the compound up to one-half inch thick by means of a trowel. The joint compound shall cure to a firm, stiff plastic condition after application. The material shall be of a uniform mixture and any small separation occurring in the container shall be stirred to a uniform mix before use.

This material shall meet the following requirements when tested in accordance with Test Method Tex-5267-C:

- Asphalt Base, 100% - % Volatiles -
  %Ash, % by weight....................... 28-45
- Volatiles, 212 F Evaporation, 24 h,
  % by weight..................................... 10-26
- Mineral Matter, determined as Ash,
  % by weight..................................... 30-55
- Consistency, Cone Penetration,
  150 q, 5 sec, 77F.......................... 150-275

C. Rubber Gaskets: These gaskets shall conform to ASTM C361 or C443. The design of the joints and permissible variations in dimensions shall be in accordance with ASTM C443. The Contractor shall furnish by the Manufacturer’s Certificate of Analysis

D. Cold Applied Preformed Plastic Gaskets. Preformed plastic gaskets shall be suitable for sealing joints of tongue and groove concrete pipe. The gasket sealing the joint shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents, irritating fumes or obnoxious odors. The gasket joint sealer shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength, and shall be supplied in extruded rope-form of suitable cross section. The size of the plastic gasket joint sealer shall be in accordance with the manufacturer’s recommendations and be of sufficient size to properly seal the joint. The plastic gasket joint sealer shall be so constructed as to provide evidence of proper installation either by means of “squeeze–out “ of the gasket material on the inside or outside around the complete pipe joint circumference or by means of tabs, projections or other such indicators placed at established intervals around the circumference of the pipe joint. Plastic
gasket joint sealers shall be Type 1 or Type 2. Type 1 gaskets shall meet the “squeeze-out” requirements and Type 2 gaskets shall meet the requirements for tabs, projections or other indicators. The gaskets joint sealer shall be protected by a suitable wrapper designed that when removed, the jointing material maintains integrity.

The chemical composition of the gasket joint sealing compound for Type 1 and 2, as shipped, shall meet the following requirements:

<table>
<thead>
<tr>
<th>COMPOSITION TEST</th>
<th>METHOD</th>
<th>ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen, Petroleum Plastic</td>
<td>ASTM D4</td>
<td>50-70</td>
</tr>
<tr>
<td>Content % by weight</td>
<td>Tex-526-C</td>
<td>30-50</td>
</tr>
<tr>
<td>Ash-Inert Mineral Matter % by weight</td>
<td>Tex-506-C</td>
<td>2.0 max.</td>
</tr>
<tr>
<td>Volatile Matter, 325 F, % by weight</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The gasket joint sealing compound when immersed for 30 days at ambient room temperature separately in five (5) percent solution of caustic potash; a five (5) percent solution of caustic potash; a five (5) percent solution of hydrochloric acid; a five (5) percent solution of sulfuric acid; and a saturated H-S solution, shall show no visible deterioration.

The physical properties of the gasket joint sealing compound as shipped shall meet the following requirements:

<table>
<thead>
<tr>
<th>PROPERTY REQUIREMENT</th>
<th>TEST METHOD</th>
<th>TYPE 1</th>
<th>TYPE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductility @ 77 F (cm), min.</td>
<td>Tex-503-C</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Softening Point °F</td>
<td>Tex-503-C</td>
<td>275</td>
<td>275</td>
</tr>
</tbody>
</table>

Penetration:

<table>
<thead>
<tr>
<th>Penetration</th>
<th>Test Method</th>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 °F (300g) 60 sec., min.</td>
<td>Tex-502-C</td>
<td>--</td>
<td>65</td>
</tr>
<tr>
<td>77 °F (150g) 5 sec.</td>
<td>Tex-502-C</td>
<td>50-120</td>
<td>50-120</td>
</tr>
<tr>
<td>115 °F (150g) 5 sec., max.</td>
<td>Tex-502-C</td>
<td>--</td>
<td>150</td>
</tr>
</tbody>
</table>

E. Construction Methods: The location of private driveway and side road pipe shall be constructed at locations shown on the plans. Reinforced concrete pipe culverts and sewers shall be constructed in accordance with the plans and requirements of this Item.

F. Excavation. All excavation shall be in accordance with the requirements of Section 02316, Excavation and Backfill for Conduits, except where tunneling or jacking methods are shown on the plans.

2.5 OUTFALLS
A. General: Construct of cast-in-place reinforced concrete pipe, head wall, apron, tapered sides, and with rip rap, as indicated.

2.6 CONCRETE AND REINFORCEMENT
1. Cement: ASTM C 150, Type II.

B. Reinforcement: Steel conforming to the following:
2. Reinforcement Bars: ASTM A 615, Grade 60, deformed.

PART 3 - EXECUTION

3.1 PREPARATION OF FOUNDATION FOR BURIED STORM SEWERAGE SYSTEMS

A. Grade trench bottom to provide a smooth, firm, stable and rock-free foundation, throughout the length of the pipe.

B. Remove unstable, soft and unsuitable materials at the surface upon which pipes are to be laid, and backfill with bedding material to indicated level.

C. Provide embedment as shown on the plans.

D. Shape bottom of trench to fit bottom of pipe. Fill unevenness with tamped bedding material. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.

3.2 GENERAL INSTALLATION

A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of the underground storm sewerage system piping. Location and arrangement of piping layout take into account many design considerations, install the piping as indicated, to the extent practical.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves and couplings in accordance with manufacturers recommendations for use of lubricants, cements and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. Use manholes or catch basins for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated.

D. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited.

E. Extend storm sewerage system piping to connect to building storm drains, of sizes and in locations indicated.

F. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking or a combination of both.

3.3 PIPE AND TUBE JOINT CONSTRUCTION AND INSTALLATION

A. Join and install PVC pipe as follows:
   1. Solvent cement joint pipe and fittings, joining with solvent cement in accordance with ASTM D 2855 and ASTM F 402.
   2. Pipe and gasketed fittings, joining with elastomeric seals in accordance with ASTM D 3212.
   3. Installation in accordance with ASTM D 2321.

B. Join concrete pipe and fittings with rubber gaskets in accordance with ASTM C 443, and install piping in accordance with applicable provisions of ACPA Concrete Pipe Installation Manual.

C. Join different types of pipe with standard manufactured couplings and fittings intended for
that purpose.

3.4 MANHOLES
A. General: Install manholes complete with accessories as indicated. Form continuous concrete or split pipe section channel and benches between inlets and outlets. Set tops of frames and covers flush with finish surface where manholes occur in pavements. Elsewhere, set tops 3 inches above finish surface, unless otherwise indicated.

B. Place precast concrete manhole sections as indicated and install in accordance with ASTM C 891.

C. Construct cast-in-place manholes as indicated.

D. Provide rubber joint gasket complying with ASTM C 443 at joint of sections.

E. Apply bituminous mastic coating at joints of sections.

3.5 CATCH BASINS
A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.6 OUTFALLS
A. Construct outfalls of the type and material as indicated on the plans.

3.7 TAP CONNECTIONS
A. Make connections to existing piping and underground structures so that finished work will conform as nearly as practicable to the requirement specified for new work.

B. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of 3000-psi 28 day compressive strength concrete.

C. Make branch connections from side into existing 24-inch or larger piping or to underground structures by cutting opening into existing unit sufficiently large to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall, unless otherwise indicated. On outside of pipe or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
   1. Provide concrete that will attain minimum 28-day compressive strength of 3000 psi, unless otherwise indicated.
   2. Use epoxy bonding compound as interface between new and existing concrete and piping materials.

E. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous materials that may accumulate.

3.8 CLOSING ABANDONED STORM, SEWERAGE SYSTEM
A. Abandoned Piping: Close open ends of abandoned underground piping that is indicated to remain in place. Provide sufficiently strong closures to withstand hydrostatic or earn pressure that may result after ends of abandoned utilities have been closed.
   1. Close open ends of concrete or masonry utilities with not less than 8-inch-thick brick
masonry bulkheads.

2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Wood plugs are not acceptable.

B. Abandoned Structures: Remove structure and close open ends of the remaining piping or remove top of structure down to not less than 3 feet below final grade; fill structure with stone, rubble, gravel or compacted dirt, to within 1 foot of top of structure remaining and fill with concrete.

3.9 FIELD QUALITY CONTROL

A. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place plugs in ends of uncompleted pipe at end of day or whenever work stops.
3. Flush piping between manholes, if required by local authority, to remove collected debris.

B. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.

1. Make inspections after pipe between manholes and manhole locations has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, correct such defects and inspect.

END OF SECTION