CITY OF RICHMOND, VIRGINIA
DEPARTMENT OF PUBLIC UTILITIES

RICHMOND MODERN GREEN HVAC PROJECT

DIVISION 01 GENERAL REQUIREMENTS
AND
TECHNICAL SPECIFICATIONS

SEPTEMBER 11, 2019 – REV. 01

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SECTION 011000 – SUMMARY

PART 1 – GENERAL

1.1 WORK COVERED BY CONTRACT DOCUMENTS

A. Project Identification: Project consists of renovating the HVAC system located in the headquarters of the Department of Public Utilities.
   1. Project Location: 400 Jefferson Davis Highway, Richmond, VA 23224.
   2. Owner: City of Richmond, Department of Public Utilities.

B. Engineer Identification: The Contract Documents, dated September 11, 2019, were prepared for Project by CHA Consulting, Inc. 9020 Stony Point Parkway #160, Richmond, Virginia 23235.

C. The Work consists of renovating the HVAC system located in the headquarters of the Department of Public Utilities.
   1. The Demolition Work is shown on backgrounds that match existing conditions, walls and area configurations. Replacement system work outlined in our project scope is shown on Architectural backgrounds that are to be defined and provided at a future date by the Owner.
   2. The Work includes the following equipment:
      b. Two Cell Cooling Tower and associated equipment.
      c. Shell and Tube Heat Exchanger.
      d. Low Temperature HHW System; Condensing Boiler.

1.2 CONTRACT

A. Project will be constructed under a general construction contract.

1.3 USE OF PREMISES

1.4 General: The facility will be occupied by the owner during construction. Work must be coordinated around the owner occupied areas.

A. Cooperate fully with separate contractors so work on those contracts may be carried out smoothly, without interfering with or delaying work under this Contract.

1.5 SPECIFICATION FORMATS AND CONVENTIONS

A. Specification Format: The Specifications are organized into Divisions and Sections using the 48-division format and CSI/CSC’s "MasterFormat" numbering system.
   1. Section Identification: The Specifications use section numbers and titles to help cross-referencing in the Contract Documents. Sections in the Project Manual are in numeric sequence; however, the sequence is incomplete. Consult the table of contents at the beginning of the Project Manual to determine numbers and names of sections in the Contract Documents.

B. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
1. Abbreviated Language: Language used in the Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be inferred as the sense requires. Singular words shall be interpreted as plural, and plural words shall be interpreted as singular where applicable as the context of the Contract Documents indicates.

2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by Contractor. Occasionally, the indicative or subjunctive mood may be used in the Section Text for clarity to describe responsibilities that must be fulfilled indirectly by Contractor or by others when so noted.

   a. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.

1.6 MISCELLANEOUS PROVISIONS

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 SCHEDULE OF PRODUCTS ORDERED IN ADVANCE

END OF SECTION
DEPARTMENT OF PUBLIC UTILITIES
MODERN GREEN HIGH-EFFICIENCY
HVAC PROJECT

PROJECT SPECIFICATIONS

SEPTEMBER 11, 2019
REVISION 01

CHA PROJECT #: 28717

Prepared for:
CITY OF RICHMOND, VIRGINIA

Prepared by:
CHA CONSULTING, INC.
9020 Stony Point Parkway, Suite 160
Richmond, VA 23235
(804) 897-3564
CITY OF RICHMOND, VIRGINIA  
DEPARTMENT OF PUBLIC UTILITIES  

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1.6 MISCELLANEOUS PROVISIONS

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 SCHEDULE OF PRODUCTS ORDERED IN ADVANCE

END OF SECTION
SECTION 011400 – WORK RESTRICTIONS

PART 1 – GENERAL

1.1 USE OF PREMISES

A. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated.
   1. Limits: Confine constructions operations to areas within the contract limits indicated.
   2. Owner Occupancy: Allow for Owner occupancy of site.
   3. Driveways and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
      a. Schedule deliveries to minimize use of driveways and entrances.
      b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on site.

B. Use of Existing Building: Maintain existing building in a weathertight condition throughout construction period. Repair damage caused by construction operations. Protect building and its occupants during construction period.

1.2 OCCUPANCY REQUIREMENTS

A. Full Owner Occupancy: Owner will occupy site and existing building during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's operations.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:
   1. Coordination.
   2. Submittals.
   3. Administrative and supervisory personnel.
   4. Project meetings.
   5. General installation provisions.
   6. Cleaning and protection.

B. Where applicable, each prime Contractor shall participate in these coordination requirements, even though certain areas of responsibility are assigned to a specific prime Contractor.

1.2 COORDINATION

A. Coordination: Coordinate construction activities included under various Sections of these Specifications to assure efficient and orderly installation of each part of the Work. Coordinate construction operations included under different Sections of these Specifications that are dependent upon each other for proper installation, connection, and operation.

B. Coordination: Each prime contractor shall cooperate with Owner’s, coordinate construction activities to assure efficient and orderly installation of each part of the Work.
   1. Where installation of one part of the Work is dependent on installation of other components, either before or after its own installation, cooperate with scheduled construction activities in the sequence required to obtain the best results.
   2. Where availability of space is limited, coordinate installation of different components to assure maximum accessibility for required maintenance, service and repair.
   3. Make adequate provisions to accommodate items scheduled for later installation.
   4. Coordinate construction activities with public and private utilities.
      a. Notify The City of Richmond Department of Public Utilities a minimum of 48 hours prior to excavation or blasting.
      b. Notify the Owner and Engineer of any utility locations encountered which conflict with the work. Coordinate with the Owner and Utility Company in the protection, removal, relocation or replacement of conflicting utility locations.

C. Where necessary, prepare memoranda for distribution to each party involved outlining special procedures required for coordination. Include such items as required notices, reports, and attendance at meetings.
   1. Prepare similar memoranda for the Owner and separate Contractors where coordination of their Work is required.

D. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
1. Preparation of Contractor's Construction Schedule.
2. Preparation of the Schedule of Values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Pre-installation conferences.
7. Project closeout activities.

E. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.
1. Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work. Refer to other Sections for disposition of salvaged materials that are designated as Owner’s property.

1.3 SUBMITTALS

A. Coordination Drawings: Prepare and submit coordination Drawings where close and careful coordination is required for installation of products and materials fabricated off-site by separate entities, and where limited space availability necessitates maximum utilization of space for efficient installation of different components.
1. Show the interrelationship of components shown on separate Shop Drawings.
2. Indicate required installation sequences.
3. Comply with requirements contained in Section “Submittals Procedures.”
4. Refer to Section “Basic Mechanical Materials and Methods,” Section “Coordinated Shop Drawings,” and Section “Basic Electrical Requirements” for specific coordination Drawing requirements for mechanical and electrical installations.

B. Staff Names: Within 15 days of starting construction operations, submit a list of principal staff assignments, including superintendent and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.
1. Post copies of list in Project meeting room, in temporary field office, and by each temporary telephone.

1.4 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site, unless otherwise indicated.
1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Engineer of scheduled meeting dates and times.
2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
3. Minutes: Record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Engineer, within 3 days of the meeting.

B. Preconstruction Conference: Schedule a preconstruction conference and organizational meeting at the Project site or other convenient site prior to commencement of construction activities. Conduct the meeting to review responsibilities and personnel assignments.
1. Attendees: Authorized representatives of Owner, the Engineer, Engineer and their consultants; the Contractor and its superintendent; major subcontractors; manufacturers; suppliers and other
concerned parties shall each be represented at the conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Discuss items of significance that could affect progress, including the following:
   a. Tentative construction schedule.
   b. Phasing.
   c. Critical work sequencing.
   d. Designation of responsible personnel.
   e. Procedures for processing field decisions and Change Orders.
   f. Procedures for processing Applications for Payment.
   g. Distribution of the Contract Documents.
   h. Submittal procedures.
   i. Preparation of Record Documents.
   j. Use of the premises.
   k. Responsibility for temporary facilities and controls.
   l. Parking availability.
   m. Office, work, and storage areas.
   n. Equipment deliveries and priorities.
   o. Safety procedures.
   p. First aid.
   q. Security.
   r. Progress cleaning.
   s. Working hours.
   t. Housekeeping.
   u. Subcontractors.
   v. Preliminary Schedule of Shop Drawings and Samples.
   w. Minority Business Enterprise Goals.
   x. Co-ordination with other contractors.
   y. Insurance in Force.
   z. Contractor's Schedule of Values.

C. Pre-installation Conferences: Conduct a pre-installation conference at Project site before each construction activity that requires coordination with other construction.
   1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise the Engineer of scheduled meeting dates.
   2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration at each pre-installation conference, including requirements for the following:
      b. Options.
      c. Related Change Orders.
      d. Purchases.
      e. Deliveries.
      f. Shop Drawings, Product Data and quality control Samples.
      g. Review of mockups.
      h. Possible conflicts.
i. Compatibility problems.

j. Time schedules.

k. Weather limitations.

l. Manufacturer’s written recommendations.

m. Warranty requirements.

n. Compatibility of materials.

o. Acceptability of substrates.

p. Temporary facilities and controls.

q. Space and access limitations.

r. Governing regulations.

s. Testing and inspecting requirements.

t. Required performance results.

u. Protection of construction and personnel.

v. Safety.

w. Recording requirements.

3. Record significant discussions, agreements and disagreements of each conference along with the approved progress schedule. Distribute the record of the meeting to everyone concerned, promptly, including the Owner and Engineer.

4. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.

D. Progress Meetings: Conduct progress meetings at the Project Site at regularly scheduled intervals. Coordinate dates of meetings with preparation of payment requests.

1. Attendees: In addition to representatives of the Owner and Engineer, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to the current status of Project.

   a. Contractor’s Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor’s Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

   b. Review present and future needs of each entity present, including the following:

      1) Interface requirements.
      2) Time.
      3) Sequence of operations.
      4) Status of submittals.
      5) Deliveries.
      6) Off-site fabrication.
      7) Access.
      8) Site utilization.
      9) Temporary facilities and controls.
10) Work hours.
11) Hazards and risks.
12) Progress cleaning.
13) Quality and work standards.
14) Change Orders.
15) Documentation of information for payment requests.

3. Reporting: No later than 3 days after each progress meeting date, distribute copies of minutes of the meeting to each party present and to parties who should have been present. Include a brief summary, in narrative form, of progress since the previous meeting and report.

a. Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue the revised schedule concurrently with the report of each meeting.

E. Coordination Meetings: Conduct Project coordination meetings at regularly scheduled intervals. Project coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and pre-installation conferences.

1. Attendees: In addition to representatives of the Owner and Engineer, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Review and correct or approve minutes of the previous coordination meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

a. Combined Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to Combined Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

b. Schedule Updating: Revise Combined Contractor's Construction Schedule after each coordination meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.

c. Review present and future needs of each contractor present, including the following:
   1) Interface requirements.
   2) Time.
   3) Sequence of operations.
   4) Status of submittals.
   5) Deliveries.
   6) Off-site fabrication.
   7) Access.
   8) Site utilization.
   9) Temporary facilities and controls.
   10) Work hours.
   11) Hazards and risks.
   12) Progress cleaning.
   13) Quality and work standards.
   14) Change Orders.
3. Reporting: Record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting.

PART 2 – PRODUCTS (Not Applicable)

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION PROVISIONS

A. Inspection of Conditions: Require the Installer of each major component to inspect both the substrate and conditions under which Work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Manufacturer’s Instructions: Comply with manufacturer’s installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in Contract Documents.

C. Inspect materials or equipment immediately upon delivery and again prior to installation. Reject damaged and defective items.


E. Visual Effects: Provide uniform joint widths in exposed Work. Arrange joints in exposed Work to obtain the best visual effect. Refer questionable choices to the Engineer for final decision.

F. Recheck measurements and dimensions, before starting each installation.

G. Install each component during weather conditions and Project status that will ensure the best possible results. Isolate each part of the completed construction from incompatible material as necessary to prevent deterioration.

H. Coordinate temporary enclosures with required inspections and tests, to minimize the necessity of uncovering completed construction for that purpose.

I. Mounting Heights: Where mounting heights are not indicated, install individual components at standard mounting heights recognized within the industry for the particular application indicated. Refer questionable mounting height decisions to the Engineer for final decision.

3.2 CLEANING AND PROTECTION

A. During handling and installation, clean and protect construction in progress and adjoining materials in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

B. Clean and maintain completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

C. Limiting Exposures: Supervise construction activities to ensure that no part of the construction completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious
exposure during the construction period. Where applicable, such exposures include, but are not
limited to, the following:

1. Excessive static or dynamic loading.
2. Excessive internal or external pressures.
3. Excessively high or low temperatures.
4. Thermal shock.
5. Excessively high or low humidity.
6. Air contamination or pollution.
7. Water or ice.
8. Solvents.
10. Light.
11. Radiation.
12. Puncture.
13. Abrasion.
14. Heavy traffic.
15. Soiling, staining and corrosion.
16. Bacteria.
17. Rodent and insect infestation.
19. Electrical current.
20. High speed operation.
21. Improper lubrication.
22. Unusual wear or other misuse.
23. Contact between incompatible materials.
24. Destructive testing.
25. Misalignment.
26. Excessive weathering.
27. Unprotected storage.
28. Improper shipping or handling.
29. Theft.
30. Vandalism.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other miscellaneous submittals.

1.2 DEFINITIONS

A. Action Submittals: Written and graphic information that requires Engineer's responsive action.

B. Informational Submittals: Written information that does not require Engineer's approval. Submittals may be rejected for not complying with requirements.

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.


1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS:

A. Engineer's Digital Data Files: Electronic digital data files of the Contract Drawings will not be provided by Engineer for Contractor's use in preparing submittals.

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 each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   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 reserve** the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on **Engineer's** receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Initial Review: Allow **15** days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. **Engineer** will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.

3. Resubmittal Review: Allow ten (10) days for review of each resubmittal.

4. Sequential Review: Where sequential review of submittals by Engineer's consultants, Owner, or other parties is indicated, allow 15 days for initial review of each submittal. Insert list of submittals requiring sequential review in first subparagraph below, or delete and identify submittals in Sections where they are specified. Structural, HVAC, plumbing, and electrical components are examples of the Work that often require sequential review.

5. Concurrent Consultant Review: Where the Contract Documents indicate that submittals may be transmitted simultaneously to Engineer and to Engineer's consultants, allow 15 days for review of each submittal. Submittal will be returned to Engineer before being returned to Contractor.

D. Paper Submittals: Place a permanent label or title block on each submittal item for identification.

1. Indicate name of firm or entity that prepared each submittal on label or title block.

2. Provide a space approximately 6 by 8 inches on label or beside title block to record Contractor's review and approval markings and action taken by Engineer.

3. Include the following information for processing and recording action taken:
   a. Project name.
   b. Date.
   c. Name of Engineer.
   d. Name of Construction Manager.
   e. Name of Contractor.
   f. Name of subcontractor.
   g. Name of supplier.
   h. Name of manufacturer.
   i. Submittal number or other unique identifier, including revision identifier.
      1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 061000.01.A).
   j. Number and title of appropriate Specification Section.
   k. Drawing number and detail references, as appropriate.
   l. Location(s) where product is to be installed, as appropriate.
   m. Other necessary identification.

4. Additional Paper Copies: Unless additional copies are required for final submittal, and unless Engineer observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.
   a. Submit one copy of submittal to concurrent reviewer in addition to specified number of copies to Engineer.

5. Transmittal for Paper Submittals: Assemble each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. Engineer will discard submittals received from sources other than Contractor.
   a. Transmittal Form for Paper Submittals: Provide locations on form for the following information:
      1) Project name.
      2) Date.
      3) Destination (To:).
      4) Source (From:).
5) Name and address of Engineer.
6) Name of Construction Manager.
7) Name of Contractor.
8) Name of firm or entity that prepared submittal.
9) Names of subcontractor, manufacturer, and supplier.
10) Category and type of submittal.
11) Submittal purpose and description.
12) Specification Section number and title.
13) Specification paragraph number or drawing designation and generic name for each of multiple items.
14) Drawing number and detail references, as appropriate.
15) Indication of full or partial submittal.
16) Transmittal number, numbered consecutively.
17) Submittal and transmittal distribution record.
18) Remarks.
19) Signature of transmitter.

E. 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-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).
3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer.
4. Transmittal Form for Electronic Submittals: Use electronic form acceptable to Owner, containing the following information:
   a. Project name.
   b. Date.
   c. Name and address of Engineer.
   d. Name of Construction Manager.
   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.

F. Options: Identify options requiring selection by Engineer.

G. Deviations and Additional Information: On an attached separate sheet, prepared on Contractor's letterhead, record 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.

H. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.
   1. Note date and content of previous submittal.
   2. Note date and content of revision in label or title block and clearly indicate extent of revision.
   3. Resubmit submittals until they are marked with approval notation from Engineer's action stamp.

I. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

J. 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 action stamp.

PART 2 – PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
   1. Post electronic submittals as PDF electronic files directly to Engineer's FTP site specifically established for Project.
      a. Engineer will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.
   2. Submit electronic submittals via email as PDF electronic files.
      a. Engineer will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.
   3. Action Submittals: Submit three (3) paper copies of each submittal unless otherwise indicated. Engineer will return two (2) copies.
   4. 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. Provide a notarized statement on original paper copy certificates and certifications where indicated.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
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.
5. Submit Product Data before or concurrent with Samples.
6. Submit Product Data in the following format:
   a. PDF electronic file.
   b. Three (3) paper copies of Product Data unless otherwise indicated. Engineer will return two (2) copies.

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. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches, but no larger than 30 by 42 inches.
3. Submit Shop Drawings in the following format:
   a. PDF electronic file.
   b. Submit five (5) opaque copies of each submittal. Engineer will retain three (3) copies; remainder will be returned.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.
1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:
   a. Generic description of Sample.
   b. Product name and name of manufacturer.
   c. Sample source.
   d. Number and title of applicable Specification Section.
   e. Specification paragraph number and generic name of each item.

3. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for record.

4. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.
   a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
   b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.

5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
   a. Number of Samples: Submit one (1) full set of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Engineer will return submittal with options selected.

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

F. Test and Inspection Reports and Schedule of Tests and Inspections Submittals: Comply with requirements specified in Division 01 Section "Quality Requirements."

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

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

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.

U. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.2 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
   1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.
B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file and three (3) paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 – EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Review each submittal and check for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer.

B. 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. General: Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.

B. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or modifications required, and return it. Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action taken, as follows:

1. Final Unrestricted Release: Where submittals are marked “No Exceptions Taken,” that part of the Work covered by the submittal may proceed provided it complies with requirements of the Contract Documents; final acceptance will depend upon that compliance.

2. Final-But-Restricted Release: When submittals are marked “Make Corrections Noted,” that part of the Work covered by the submittal may proceed provided it complies with notations or corrections on the submittal and requirements of the Contract Documents; final acceptance will depend on that compliance.

3. Returned for Resubmittal: When submittal is marked “Revise and Resubmit,” “Rejected,” or “Submit Specified Item,” do not proceed with that part of the Work covered by the submittal, including purchasing, fabrication, delivery, or other activity. Revise or prepare a new submittal in accordance with the notations; resubmit without delay. Repeat if necessary to obtain a different action mark.

   a. Do not permit submittals marked “Revise and Resubmit,” “Rejected,” or “Submit Specified Item” to be used at the Project site, or elsewhere where Work is in progress.

4. Other Action: Where a submittal is primarily for information or record purposes, special processing or other activity, the submittal will be returned, marked “Action Not Required.”

C. Submittals not required by the Contract Documents will not be reviewed and may be discarded.

END OF SECTION
SECTION 014000 – QUALITY REQUIREMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for quality assurance and quality control.

B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
   1. Specific quality-control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
   2. Specified tests, inspections, and related actions do not limit Contractor's quality-control procedures that facilitate compliance with the Contract Document requirements.
   3. Requirements for Contractor to provide quality-control services required by Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.

1.2 DEFINITIONS

A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and ensure that proposed construction complies with requirements.

B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that completed construction complies with requirements. Services do not include contract enforcement activities performed by Engineer.

C. Mockups: Full-size, physical example assemblies to illustrate finishes and materials. Mockups are used to verify selections made under Sample submittals, to demonstrate aesthetic effects and, where indicated, qualities of materials and execution, and to review construction, coordination, testing, or operation; they are not Samples.

D. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.

1.3 DELEGATED DESIGN

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
   1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.

1.4 SUBMITTALS

A. Qualification Data: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.
B. Delegated-Design Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit a statement, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional, indicating that the products and systems are in compliance with performance and design criteria indicated. Include list of codes, loads, and other factors used in performing these services.

C. Schedule of Tests and Inspections: Prepare in tabular form and include the following:
   1. Specification Section number and title.
   2. Description of test and inspection.
   3. Identification of applicable standards.
   4. Identification of test and inspection methods.
   5. Number of tests and inspections required.
   6. Time schedule or time span for tests and inspections.
   7. Entity responsible for performing tests and inspections.
   8. Requirements for obtaining samples.
   9. Unique characteristics of each quality-control service.

D. Reports: Prepare and submit certified written reports that include the following:
   1. Date of issue.
   2. Project title and number.
   3. Name, address, and telephone number of testing agency.
   4. Dates and locations of samples and tests or inspections.
   5. Names of individuals making tests and inspections.
   6. Description of the Work and test and inspection method.
   8. Complete test or inspection data.
   9. Test and inspection results and an interpretation of test results.
   10. Ambient conditions at time of sample taking and testing and inspecting.
   11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
   12. Name and signature of laboratory inspector.
   13. Recommendations on retesting and reinspecting.

E. Permits, Licenses, and Certificates: For Owner's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

B. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
C. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

D. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance.

E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or products that are similar to those indicated for this Project in material, design, and extent.

F. Specialists: Certain sections of the Specifications require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
   1. Requirement for specialists shall not supersede building codes and similar regulations governing the Work, nor interfere with local trade-union jurisdictional settlements and similar conventions.

G. Testing Agency Qualifications: An agency with the experience and capability to conduct testing and inspecting indicated, as documented by ASTM E548, and that specializes in types of tests and inspections to be performed. Each testing agency shall be authorized by the authorities having jurisdiction in the state in which the project is located.

H. Preconstruction Testing: Testing agency shall perform preconstruction testing for compliance with specified requirements for performance and test methods.
   1. Contractor responsibilities include the following:
      a. Provide test specimens and assemblies representative of proposed materials and construction. Provide sizes and configurations of assemblies to adequately demonstrate capability of product to comply with performance requirements.
      b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
      c. Fabricate and install test assemblies using installers who will perform the same tasks for Project.
      d. When testing is complete, remove assemblies; do not reuse materials on Project.
   2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Engineer through Construction Manager, with copy to Contractor. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.

I. Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:
   1. Build mockups in location and of size indicated or, if not indicated, as directed by Engineer.
   2. Notify Engineer [7] days in advance of dates and times when mockups will be constructed.
   3. Demonstrate the proposed range of aesthetic effects and workmanship.
   4. Obtain Engineer's approval of mockups before starting work, fabrication, or construction.
   5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   6. Demolish and remove mockups when directed, unless otherwise indicated.
1.6 QUALITY CONTROL

A. Owner Responsibilities: Where quality-control services are indicated as Owner's responsibility, Owner will engage a qualified testing agency to perform these services.
   1. Owner will furnish Contractor with names, addresses, and telephone numbers of testing agencies engaged and a description of the types of testing and inspecting they are engaged to perform.
   2. 

B. Contractor Responsibilities: Unless otherwise indicated, provide quality-control services specified and required by authorities having jurisdiction.
   1. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality-control services.
      a. Contractor shall not employ the same entity engaged by Owner, unless agreed to in writing by Owner.
   2. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspecting will be performed.
   3. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
   4. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
   5. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

C. Special Tests and Inspections: Owner will engage a testing agency to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of Owner.
   1. Testing agency will notify Engineer and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
   2. Testing agency will submit a certified written report of each test, inspection, and similar quality-control service to Engineer with copy to Contractor and to authorities having jurisdiction.
   3. Testing agency will submit a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
   4. Testing agency will interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.
   5. Testing agency will retest and reinspect corrected work.

D. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing.

E. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that revised or replaced Work that failed to comply with requirements established by the Contract Documents.

F. Testing Agency Responsibilities: Cooperate with Engineer and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
   1. Notify Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
2. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
3. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
4. Do not release, revoke, alter, or increase requirements of the Contract Documents or approve or accept any portion of the Work.
5. Do not perform any duties of Contractor.

G. Associated Services: Cooperate with agencies performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
1. Access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
4. Facilities for storage and field-curing of test samples.
5. Delivery of samples to testing agencies.
6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
7. Security and protection for samples and for testing and inspecting equipment at Project site.

H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
1. Schedule times for tests, inspections, obtaining samples, and similar activities.

I. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents. Submit schedule within 30 days of date established for commencement of the Work.
1. Distribution: Distribute schedule to Owner, Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 REPAIR AND PROTECTION

A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
1. Provide materials and comply with installation requirements specified in other Sections of these Specifications. Restore patched areas and extend restoration into adjoining areas in a manner that eliminates evidence of patching.
2. Comply with the Contract Document requirements for Division 1 Section "Cutting and Patching."

B. Protect construction exposed by or for quality-control service activities.
C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION
SECTION 017300 – EXECUTION REQUIREMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes general procedural requirements governing execution of the Work including, but not limited to, the following:
   2. Field engineering and surveying.
   4. Coordination of Owner-installed products.
   5. Progress cleaning.
   6. Starting and adjusting.
   7. Protection of installed construction.
   8. Correction of the Work.

1.2 SUBMITTALS

A. Qualification Data: For professional engineer to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

B. Certificates: Submit certificate signed by professional engineer certifying that location and elevation of improvements comply with requirements.

1.3 QUALITY ASSURANCE

A. Land Surveyor Qualifications: A professional land surveyor who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing land-surveying services of the kind indicated.

B. Engineer’s Qualifications: A professional Engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 EXAMINATION

A. Existing Conditions: The existence and location of site improvements, utilities, and other construction indicated as existing are not guaranteed. Before beginning work, investigate and verify the existence and location of mechanical and electrical systems and other construction affecting the Work.
   1. Before construction, verify the location and points of connection of utility services.
B. Existing Utilities: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities and other construction affecting the Work.
   1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; and underground electrical services.
   2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

C. Acceptance of Conditions: Examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.
   1. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:
      a. Description of the Work.
      b. List of detrimental conditions, including substrates.
      c. List of unacceptable installation tolerances.
      d. Recommended corrections.
   2. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
   3. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
   4. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
   5. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Existing Utility Information: Furnish information to the City of Richmond that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify the Richmond Department of Public Utilities not less than 48 hours in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Owner’s written permission.

C. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

D. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

3.3 CONSTRUCTION LAYOUT

A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify Engineer promptly.

B. Building Lines and Levels: Locate and lay out control lines and levels for structures, building foundations, column grids, and floor levels, including those required for mechanical and electrical work. Transfer survey markings and elevations for use with control lines and levels. Level foundations and piers from two or more locations.

3.4 FIELD ENGINEERING

A. Identification: Owner will identify existing benchmarks, control points, and property corners.

B. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.
   1. Do not change or relocate existing benchmarks or control points without prior written approval of Engineer. Report lost or destroyed permanent benchmarks or control points promptly.
   2. Report the need to relocate permanent benchmarks or control points to Engineer before proceeding.
   3. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.

3.5 INSTALLATION

A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
   1. Make vertical work plumb and make horizontal work level.
   2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
   3. Conceal pipes, ducts, and wiring in finished areas, unless otherwise indicated.
   4. Maintain minimum headroom clearance of 8 feet in spaces without a suspended ceiling.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

E. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.

F. Anchors and Fasteners: Provide anchors and fasteners as required to anchor each component securely in place, accurately located and aligned with other portions of the Work.
   1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Engineer.
   2. Allow for building movement, including thermal expansion and contraction.
G. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

H. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.6 OWNER-INSTALLED PRODUCTS

A. Site Access: Provide access to Project site for Owner's construction forces.

B. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction forces.
   1. Construction Schedule: Inform Owner of Contractor's preferred construction schedule for Owner's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify Owner if changes to schedule are required due to differences in actual construction progress.
   2. Preinstallation Conferences: Include Owner's construction forces at preinstallation conferences covering portions of the Work that are to receive Owner's work. Attend preinstallation conferences conducted by Owner's construction forces if portions of the Work depend on Owner's construction.

3.7 PROGRESS CLEANING

A. General: Clean Project site and work areas daily, including common areas. Coordinate progress cleaning for joint-use areas where more than one installer has worked. Enforce requirements strictly. Dispose of materials lawfully.
   2. Do not hold materials more than 7 days during normal weather or 3 days if the temperature is expected to rise above 80 deg F (27 deg C).
   3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.
   4. Do not contaminate areas of on-going work in facility.

B. Site: Maintain Project site free of waste materials and debris.

C. Work Areas: Clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
   1. Remove liquid spills promptly.
   2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.

D. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.

E. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

F. Exposed Surfaces: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.
G. Cutting and Patching: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.
   1. Thoroughly clean piping, conduit, and similar features before applying paint or other finishing materials. Restore damaged pipe covering to its original condition.

H. Waste Disposal: Burying or burning waste materials on-site will not be permitted. Washing waste materials down sewers or into waterways will not be permitted.

I. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

J. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

K. Limiting Exposures: Supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

3.8 STARTING AND ADJUSTING
A. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.

B. Adjust operating components for proper operation without binding. Adjust equipment for proper operation.

C. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Manufacturer's Field Service: If a factory-authorized service representative is required to inspect field-assembled components and equipment installation, comply with qualification requirements in Division 1 Section "Quality Requirements."

3.9 PROTECTION OF INSTALLED CONSTRUCTION
A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Comply with manufacturer's written instructions for temperature and relative humidity.

3.10 CORRECTION OF THE WORK
A. Repair or remove and replace defective construction. Restore damaged substrates and finishes. Comply with requirements in Division 1 Section "Cutting and Patching."
   1. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment.

B. Restore permanent facilities used during construction to their specified condition.

C. Remove and replace damaged surfaces that are exposed to view if surfaces cannot be repaired without visible evidence of repair.
D. Repair components that do not operate properly. Remove and replace operating components that cannot be repaired.

E. Remove and replace chipped, scratched, and broken glass or reflective surfaces.

END OF SECTION
SECTION 017329 – CUTTING AND PATCHING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes procedural requirements for cutting and patching.

B. Refer to other sections for specific requirements and limitations applicable to cutting and patching individual parts of the work.

1. Requirements in this Section apply to mechanical and electrical installations. Refer to Divisions 22, 23, and 26 Sections for other requirements and limitations applicable to cutting and patching of mechanical and electrical installations.

1.2 DEFINITIONS

A. Cutting: Removal of existing construction necessary to permit installation or performance of other Work.

B. Patching: Fitting and repair work required to restore surfaces to original conditions after installation of other Work.

1.3 SUBMITTALS

A. Cutting and Patching Proposal: Where approval of procedures for cutting and patching is required before proceeding, submit a proposal describing procedures at least 10 days before the time cutting and patching will be performed, requesting approval to proceed. Include the following information:

1. Extent: Describe the extent of cutting and patching, show how they will be performed, and indicate why they cannot be avoided.

2. Changes to Existing Construction: Describe anticipated results in terms of changes to existing construction; include changes to structural elements and operating components as well as changes in building's appearance and other significant visual elements.

3. Products: List products to be used and firms or entities that will perform the Work.

4. Dates: Indicate dates when cutting and patching will be performed.

5. Utilities: List utilities that cutting and patching procedures will disturb or affect. List utilities that will be relocated and those that will be temporarily out of service. Indicate how long service will be disrupted.

6. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure.

7. Engineer’s Approval: Obtain approval of cutting and patching proposal before cutting and patching. Approval does not waive right of the Engineer to later require removal and replacement of unsatisfactory work.

8. Describe means for the protection of adjacent areas to where cutting and patching shall take place.

1.4 QUALITY ASSURANCE

A. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio.
a. Foundation construction.
b. Bearing and retaining walls.
c. Structural concrete.
d. Structural steel.
e. Lintels.
f. Timber and primary wood framing.
g. Structural decking.
h. Stair systems.
i. Miscellaneous structural metals.
j. Shoring, bracing, and sheeting.

B. Operational Elements: Do not cut and patch operating elements or safety related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.
1. Primary operational systems and equipment.
2. Air or smoke barriers.
3. Fire-protection systems.
4. Control systems.
5. Communication systems.
6. Conveying systems.
7. Electrical wiring systems.

C. Miscellaneous Elements: Do not cut and patch the following elements or related components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety.
1. Water, moisture, or vapor barriers.
2. Membranes and flashings.
3. Exterior curtain-wall construction.
4. Equipment supports.
5. Piping, ductwork, vessels, and equipment.

D. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
1. If possible, retain original Installer or fabricator to cut and patch exposed Work listed below. If it is impossible to engage original Installer or fabricator, engage another recognized, experienced, and specialized firm.
   a. Processed concrete finishes.
   b. Stonework and stone masonry.
   c. Ornamental metal.
   d. Matched-veneer woodwork.
   e. Preformed metal panels.
   f. Roofing.
g. Firestopping.
h. Window wall system.
i. Stucco and ornamental plaster.
j. Terrazzo.
k. Finished wood flooring.
l. Fluid-applied flooring.
m. Aggregate wall coating.
n. Wall covering.
o. Swimming pool finishes.
p. HVAC enclosures, cabinets, or covers.
q. Acoustical ceilings
r. Carpeting

E. Cutting and Patching Conference: Before proceeding, meet at Project site with parties involved in cutting and patching, including mechanical and electrical trades. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.

1.5 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, by methods and with materials so as not to void existing warranties.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General: Comply with requirements specified in other Sections of these Specifications.

B. Existing Materials: Use materials identical to existing materials. For exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible.
   1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of existing materials.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Prior to cutting existing services, examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed. Take corrective action before proceeding. If unsafe or unsatisfactory conditions are encountered, investigate both sides of the surface involved. Determine exact location of structural members.
   1. Compatibility: Before patching, verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
   2. Proceed with installation only after unsafe or unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Temporary Support: Provide temporary shoring and support of Work to be cut to prevent settlement or other damage to existing construction to remain.

B. Protection: Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

C. Adjoining Areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

D. Existing Services: Where existing services are required to be removed, relocated, or abandoned, bypass such services before cutting to avoid interruption of services to occupied areas.

E. Take all precautions necessary to avoid cutting existing pipe, conduit, or ductwork serving the building, but scheduled to be removed or relocated until provisions have been made to bypass them.

3.3 PERFORMANCE

A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
   1. Cut existing construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

B. Cutting: Cut existing construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
   1. In general, where cutting is required, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
   2. Existing Finished Surfaces: To avoid marring existing finished surfaces, cut or drill from the exposed or finished side into concealed surfaces.
   3. Concrete: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
   4. Mechanical and Electrical Services: Bypass utility services such as pipe or conduit, before cutting, where services are shown or required to be moved, relocated, or abandoned. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after bypassing and cutting.
   5. Proceed with patching after construction operations requiring cutting are complete.

C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Comply with specified tolerances. Provide materials and comply with installation requirements specified in other Sections of these Specifications. Perform patching around items penetrating existing construction in a manner that will maintain the water and fire resistive capability of the existing construction.
   1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.
2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.

3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove existing floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance
   a. Where patching occurs in a painted surface, apply primer and intermediate paint coats over the patch and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.
   b. Where surfaces exposed by removals are to remain as exposed surfaces, paint such areas to match adjacent surfaces as closely as practicable using paint with the same characteristics and appearance as the existing to remain.

4. Ceilings: Patch, repair, or rehang existing ceilings as necessary to provide an even-plane surface of uniform appearance.

5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.

6. Where reinstallation of removed items is indicated, reinstall them to a condition equal to or better than their condition before removal.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
   1. Inspection procedures.
   2. Project Record Documents.
   3. Operation and maintenance manuals.
   4. Warranties.
   5. Instruction of Owner's personnel.
   6. Final cleaning.

1.2 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete in request.
   1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
   2. Advise Owner of pending insurance changeover requirements.
   3. Submit specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
   4. Obtain and submit releases permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
   5. Prepare and submit Project Record Documents, operation and maintenance manuals, Final Completion construction photographs, damage or settlement surveys, property surveys, and similar final record information.
   6. Deliver tools, spare parts, extra materials, and similar items to location designated by Owner. Label with manufacturer's name and model number where applicable.
   7. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.
   8. Complete startup testing of systems.
   10. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
   11. Advise Owner of changeover in heat and other utilities.
   12. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.
   13. Complete final cleaning requirements, including touchup painting.
   14. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Inspection: Submit a written request for inspection for Substantial Completion. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements.
   1. Engineer will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Engineer, that must be completed or corrected before certificate will be issued.
2. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
3. Results of completed inspection will form the basis of requirements for Final Completion.

1.3 FINAL COMPLETION
A. Preliminary Procedures: Before requesting final inspection for determining date of Final Completion, complete the following:
   1. Submit a final Application for Payment
   2. Submit certified copy of Engineer's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Engineer. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
   3. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems.
B. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
   1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.4 PROJECT RECORD DOCUMENTS
A. General: Do not use Project Record Documents for construction purposes. Protect Project Record Documents from deterioration and loss. Provide access to Project Record Documents for Engineer's reference during normal working hours.
B. Record Drawings: Maintain and submit one set of blue- or black-line white prints of Contract Drawings and Shop Drawings.
   1. Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.
      a. Give particular attention to information on concealed elements that cannot be readily identified and recorded later.
      b. Accurately record information in an understandable drawing technique.
      c. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.
      d. Mark Contract Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. Where Shop Drawings are marked, show cross-reference on Contract Drawings.
   2. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at the same location.
   3. Mark important additional information that was either shown schematically or omitted from original Drawings.
   4. Note Construction Change Directive numbers, Change Order numbers, alternate numbers, and similar identification where applicable.
   5. Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location. Organize into manageable sets; bind each set with durable paper cover sheets. Include identification on cover sheets.
C. Record Specifications: Submit one copy of Project's Specifications, including addenda and contract modifications. Mark copy to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
   1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
   2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
   3. Note related Change Orders, Record Drawings, and Product Data, where applicable.

D. Record Product Data: Submit one copy of each Product Data submittal. Mark one set to indicate the actual product installation where installation varies substantially from that indicated in Product Data.
   1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
   2. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.
   3. Note related Change Orders, Record Drawings, and Record Specifications, where applicable.

E. Miscellaneous Record Submittals: Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

1.5 OPERATION AND MAINTENANCE MANUALS

A. Assemble a complete set of operation and maintenance data indicating the operation and maintenance of each system, subsystem, and piece of equipment not part of a system. Include operation and maintenance data required in individual Specification Sections and as follows:
   1. Operation Data:
      a. Emergency instructions and procedures.
      b. System, subsystem, and equipment descriptions, including operating standards.
      c. Operating procedures, including startup, shutdown, seasonal, and weekend operations.
      d. Description of controls and sequence of operations.
      e. Piping diagrams.
      a. Manufacturer's information, part numbers, serial numbers, including list of spare parts.
      b. Name, address, and telephone number of Installer or supplier.
      c. Maintenance procedures.
      d. Maintenance and service schedules for preventive and routine maintenance.
      e. Maintenance record forms.
      f. Sources of spare parts and maintenance materials.
      g. Copies of maintenance service agreements.
      h. Copies of warranties and bonds.

B. Organize operation and maintenance manuals into suitable sets of manageable size. Bind and index data in heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, with pocket inside the covers to receive folded oversized sheets. Identify each binder on front and spine with the printed title "OPERATION AND MAINTENANCE MANUAL,” Project name, and subject matter of contents.
1.6 WARRANTIES

A. Submittal Time: Submit written warranties on request of Engineer for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated.

B. Partial Occupancy: Submit properly executed warranties within 15 days of completion of designated portions of the Work that are completed and occupied or used by Owner during construction period by separate agreement with Contractor. Warranties to commence after complete system commissioning and acceptance.

C. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.
   1. Bind warranties and bonds in heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
   2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
   3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.

D. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 – EXECUTION

3.1 DEMONSTRATION AND TRAINING

A. Instruction: Instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.
   1. Provide instructors experienced in operation and maintenance procedures.
   2. Provide instruction at mutually agreed-on times. For equipment that requires seasonal operation, provide similar instruction at the start of each season.
   3. Schedule training with Owner seven (7) days advance notice.

3.2 FINAL CLEANING

A. General: Provide final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:
   a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
   b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
   c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
   d. Remove tools, construction equipment, machinery, and surplus material from Project site.
   e. Remove snow and ice to provide safe access to building.
   f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
   g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
   h. Sweep concrete floors broom clean in unoccupied spaces.
   i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; shampoo if visible soil or stains remain.
   j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
   k. Remove labels that are not permanent.
   l. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
      1) Do not paint over "UL" and similar labels, including mechanical and electrical nameplates.
   m. Wipe surfaces of mechanical and electrical equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
   n. Replace parts subject to unusual operating conditions.
   o. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
   p. Clean ducts, blowers, and coils if units were operated without filters during construction.
   q. Leave Project clean and ready for occupancy.

C. Pest Control: Engage an experienced, licensed exterminator to make a final inspection and rid Project of rodents, insects, and other pests. Prepare a report.

D. Comply with safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on Owner’s property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from Project site and dispose of lawfully.

END OF SECTION
SECTION 017823 – OPERATION AND MAINTENANCE DATA

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
   1. Operation and maintenance documentation directory.
   2. Emergency manuals.
   3. Operation manuals for systems, subsystems, and equipment.
   4. Maintenance manuals for the care and maintenance of products and systems equipment.

1.2 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.
B. Subsystem: A portion of a system with characteristics similar to a system.

1.3 SUBMITTALS

A. Initial Submittal: Submit two (2) draft copies of each manual at least 15 days before requesting inspection for Substantial Completion. Include a complete operation and maintenance directory. Engineer will return one copy of draft and mark whether general scope and content of manual are acceptable.

B. Final Submittal: Submit one (1) copy of each manual in final form at least 15 days before final inspection. Engineer will return copy with comments within 15 days after final inspection.
   1. Correct or modify each manual to comply with Engineer's comments. Submit three (3) copies of each corrected manual within 15 days of receipt of Engineer's comments.

1.4 COORDINATION

A. Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, assemble and coordinate information furnished by representatives and prepare manuals.

PART 2 – PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Organization: Include a section in the directory for each of the following:
   1. List of documents.
   2. List of systems.
   3. List of equipment.
   4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.
C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with the same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

2.2 MANUALS, GENERAL

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:
   1. Title page.
   2. Table of contents.

B. Title Page: Enclose title page in transparent plastic sleeve. Include the following information:
   1. Subject matter included in manual.
   2. Name and address of Project.
   3. Name and address of Owner.
   4. Date of submittal.
   5. Name, address, and telephone number of Contractor.
   6. Name and address of Engineer.
   7. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
   1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
   1. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
      a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
      b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
   2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included
in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.

3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.


5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.3 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:
   1. Type of emergency.
   2. Emergency instructions.
   3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:
   1. Fire.
   2. Flood.
   5. Power failure.
   7. System, subsystem, or equipment failure.
   8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:
   1. Instructions on stopping.
   2. Shutdown instructions for each type of emergency.
   3. Operating instructions for conditions outside normal operating limits.
   4. Required sequences for electric or electronic systems.
   5. Special operating instructions and procedures.

2.4 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:
   1. System, subsystem, and equipment descriptions.
   2. Performance and design criteria if Contractor is delegated design responsibility.
   3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:
1. Product name and model number.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:
1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, overview of system operational profile and its functional operation logic system, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.5 PRODUCT MAINTENANCE MANUAL

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Product Information: Include the following, as applicable:
1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
1. Include procedures to follow and required notifications for warranty claims.

2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in the manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
1. Standard printed maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training videotape, if available.
E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
   1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
   2. Maintenance and Service Record: Include manufacturers’ forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
   1. Include procedures to follow and required notifications for warranty claims.

PART 3 – EXECUTION

3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.
   1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
   2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.
   1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.
1. Do not use original Project Record Documents as part of operation and maintenance manuals.
2. Comply with requirements of newly prepared Record Drawings in Division 1 Section "Project Record Documents."

G. Comply with Division 1 Section "Closeout Procedures" for the schedule for submitting operation and maintenance documentation.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for Project Record Documents, including the following:
   1. Record Drawings.
   2. Record Specifications.
   3. Record Product Data.
   4. Record Samples.

1.2 SUBMITTALS

A. Record Drawings: Comply with the following:
   1. Number of Copies: Submit one (1) set of marked-up Record Prints.

B. Record Specifications: Submit one (1) copy of Project's Specifications, including addenda and contract modifications.

PART 2 – PRODUCTS

2.1 RECORD DRAWINGS

A. Record Prints: Maintain one set of blue- or black-line white prints of the Contract Drawings and Shop Drawings.

   1. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.
      a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
      b. Accurately record information in an understandable drawing technique.
      c. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.

   2. Content: Types of items requiring marking include, but are not limited to, the following:
      a. Dimensional changes to Drawings.
      b. Revisions to details shown on Drawings.
      c. Depths of foundations below first floor.
      d. Locations and depths of underground utilities.
      e. Revisions to routing of piping and conduits.
      f. Revisions to electrical circuitry.
      g. Actual equipment locations.
      h. Duct size and routing.
      i. Locations of concealed internal utilities.
      j. Changes made by Change Order or Work Change Directive.
      k. Changes made following Engineer's written orders.
1. Details not on the original Contract Drawings.

m. Field records for variable and concealed conditions.

n. Record information on the Work that is shown only schematically.

3. Mark the Contract Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. If Shop Drawings are marked, show cross-reference on the Contract Drawings.

4. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at the same location.

5. Mark important additional information that was either shown schematically or omitted from original Drawings.

6. Note Work Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

2.2 RECORD SPECIFICATIONS

A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.

2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.

3. Record the name of the manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.

4. For each principal product, indicate whether Record Product Data has been submitted in operation and maintenance manuals instead of submitted as Record Product Data.

5. Note related Change Orders, Record Drawings, and Product Data where applicable.

2.3 RECORD PRODUCT DATA

A. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.

2. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.

3. Note related Change Orders, Record Drawings, and Product Data where applicable.

2.4 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

2.5 RECORD SAMPLE SUBMITTAL

A. Immediately prior to date of Substantial Completion, the Contractor shall meet with the Engineer and, if desired, the Owner's personnel at the site to determine which of the Samples maintained during the construction period shall be transmitted to Owner for record purposes. Comply with the Engineer's instructions for packaging, identification marking, and delivery to Owner's Sample storage space. Dispose of other Samples in manner specified for disposal of surplus and waste materials.
PART 3 – EXECUTION

3.1 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.

B. Maintenance of Record Documents and Samples: Store Record Documents and Samples in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Project Record Documents for Engineer's reference during normal working hours.

END OF SECTION
SECTION 017900 – DEMONSTRATION AND TRAINING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:
   1. Demonstration of operation of systems, subsystems, and equipment.
   2. Training in operation and maintenance of systems, subsystems, and equipment.

1.2 SUBMITTALS

A. Instruction Program: Submit two (2) copies of outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.
   1. At completion of training, submit one (1) complete training manual for Owner's use.

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of ENGINEER and OWNER, and other information specified.

C. Attendance Record: For each training module, submit list of participants and length of instruction time.

D. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

1.3 QUALITY ASSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: A factory-authorized service representative, complying with requirements in Division 1 Section "Quality Requirements," experienced in operation and maintenance procedures and training.

C. Preinstruction Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination." Review methods and procedures related to demonstration and training including, but not limited to, the following:
   1. Inspect and discuss locations and other facilities required for instruction.
   2. Review and finalize instruction schedule and verify availability of educational materials, instructors' personnel, audiovisual equipment, and facilities needed to avoid delays.
   3. Review required content of instruction.
   4. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.
1.4 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations.

B. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Engineer.

PART 2 – PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:
   1. Heat generation, including boilers, feedwater equipment, pumps, and water distribution piping.
   2. Refrigeration systems, including chillers, cooling towers, condensers, pumps, and distribution piping.
   3. HVAC systems, including air-handling equipment, air distribution systems, and terminal equipment and devices.
   4. HVAC instrumentation and controls.
   5. Electrical service and distribution, including transformers, switchboards, panelboards, uninterruptible power supplies, and motor controls.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:
   1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
      a. System, subsystem, and equipment descriptions.
      b. Performance and design criteria if Contractor is delegated design responsibility.
      c. Operating standards.
      d. Regulatory requirements.
      e. Equipment function.
      f. Operating characteristics.
      g. Limiting conditions.
      h. Performance curves.
   2. Documentation: Review the following items in detail:
      a. Emergency manuals.
      b. Operations manuals.
      c. Maintenance manuals.
      d. Project Record Documents.
      e. Identification systems.
      f. Warranties and bonds.
      g. Maintenance service agreements and similar continuing commitments.
3. Emergencies: Include the following, as applicable:
   a. Instructions on meaning of warnings, trouble indications, and error messages.
   b. Instructions on stopping.
   c. Shutdown instructions for each type of emergency.
   d. Operating instructions for conditions outside of normal operating limits.
   e. Sequences for electric or electronic systems.
   f. Special operating instructions and procedures.

4. Operations: Include the following, as applicable:
   a. Startup procedures.
   b. Equipment or system break-in procedures.
   c. Routine and normal operating instructions.
   d. Regulation and control procedures.
   e. Control sequences.
   f. Safety procedures.
   g. Instructions on stopping.
   h. Normal shutdown instructions.
   i. Operating procedures for emergencies.
   j. Operating procedures for system, subsystem, or equipment failure.
   k. Seasonal and weekend operating instructions.
   l. Required sequences for electric or electronic systems.
   m. Special operating instructions and procedures.

5. Adjustments: Include the following:
   a. Alignments.
   b. Checking adjustments.
   c. Noise and vibration adjustments.
   d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:
   a. Diagnostic instructions.
   b. Test and inspection procedures.

7. Maintenance: Include the following:
   a. Inspection procedures.
   b. Types of cleaning agents to be used and methods of cleaning.
   c. List of cleaning agents and methods of cleaning detrimental to product.
   d. Procedures for routine cleaning
   e. Procedures for preventive maintenance.
   f. Procedures for routine maintenance.
   g. Instruction on use of special tools.

8. Repairs: Include the following:
   a. Diagnosis instructions.
   b. Repair instructions.
   c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   d. Instructions for identifying parts and components.
   e. Review of spare parts needed for operation and maintenance.

9. Control System: Include the following:
   a. Walk-through of the facility to identify control panels and device locations.
b. Specific hardware configuration of installed systems, and specific instruction for operating the installed system.

c. Security levels.

d. Alarms.

e. System start-up and shut-down.

f. Power outage and restart routines.

g. Changing setpoints and alarms and other typical changed parameters.

h. Overrides.

i. Manual operation of equipment.

j. All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends.

k. Review of Every graphics screen, allowing time for questions.

l. Setting up and changing a controller.

m. Graphics generation.

n. Point database entry and modifications.

PART 3 – EXECUTION

3.1 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a combined training manual.

B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

1. Engineer will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.

2. Owner will furnish an instructor to describe Owner's operational philosophy.

3. Owner will furnish Contractor with names and positions of participants.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner, through Engineer with at least seven (7) days' advance notice.

D. Cleanup: Collect used and leftover educational materials and remove from Project site and give to Owner. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.
END OF SECTION
SECTION 051200 – STRUCTURAL STEEL FRAMING

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. Structural steel.
2. Grout.

1.3 DEFINITIONS

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, “Code of Standard Practice for Steel Buildings and Bridges.”

1.4 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication of structural-steel components:
  1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
  2. Include embedment Drawings.
  3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
  4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For fabricator, shop-painting applicators and testing agency.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
D. Mill test reports for structural steel, including chemical and physical properties.

E. Product Test Reports: For the following:
   1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
   2. Shop primers.

F. Survey of existing conditions.

G. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.

B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector.

C. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1 or to SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."

D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

E. Comply with applicable provisions of the following specifications and documents:
   1. AISC 360.
   2. RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
   1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
   1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
   2. Clean and relubricate bolts and nuts that become dry or rusty before use.
   3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F1852 fasteners and for retesting fasteners after lubrication.
PART 2 – PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A992/A992M.

B. Channels, Angles, S-Shapes: ASTM A36/A36M.

C. Plate and Bar: ASTM A36/A36M.

D. Cold-Formed Hollow Structural Sections: ASTM A500/A500M, Grade B, structural tubing.

E. Steel Pipe: ASTM A53/A53M, Type E or Type S, Grade B
   1. Finish: Black except where indicated to be galvanized.

F. Welding Electrodes: Comply with AWS requirements.

2.3 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM A325, Type 1, heavy-hex steel structural bolts; ASTM A563, Grade C, heavy-hex carbon-steel nuts; and ASTM F436, Type 1, hardened carbon-steel washers; all with plain finish.

B. Zinc-Coated High-Strength Bolts, Nuts, and Washers: ASTM A325, Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH heavy-hex carbon-steel nuts; and ASTM F436, Type 1, hardened carbon-steel washers.
   1. Finish: Hot-dip or mechanically deposited zinc coating.
   2. Total Movement Capability: 2 inches.

2.4 PRIMER

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.

C. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.5 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.6 FABRICATION

1.  Fabricate beams with rolling camber.
2.  Identify high-strength structural steel according to ASTM A6/A6M and maintain markings until structural steel has been erected.
3.  Mark and match-mark materials for field assembly.

B.  Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
1.  Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.

C.  Bolt Holes: Cut, drill, mechanically thermal cut, or punch standard bolt holes perpendicular to metal surfaces.

D.  Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E.  Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural-steel frame. Straighten as required to provide uniform, square, and true members in completed wall framing. Build up welded framing, weld exposed joints continuously, and grind smooth.

F.  Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.
1.  Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.

2.7  SHOP CONNECTIONS

A.  High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts" for type of bolt and type of joint specified.
1.  Joint Type: Snug tightened.

B.  Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

2.8  SHOP PRIMING

A.  Shop prime steel surfaces except the following:
1.  Surfaces to be field welded.
2.  Surfaces to receive sprayed fire-resistant materials (applied fireproofing).
4.  Surfaces enclosed in interior construction.

B.  Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards.
1.  SSPC-SP 2, "Hand Tool Cleaning."

C.  Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

D.  Painting: Prepare steel and apply a one-coat, nonasphaltic primer complying with SSPC-PS Guide 7.00, "Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems," to provide a dry film thickness of not less than 1.5 mils.
2.9 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A123/A123M.
   1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
   2. Galvanize lintels, shelf angles, and welded door frames attached to structural-steel frame and located in exterior walls.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform shop tests and inspections.
   1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.

B. Bolted Connections: Inspect and test shop-bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

C. Welded Connections: Visually inspect shop-welded connections according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
   1. Liquid Penetrant Inspection: ASTM E165.
   2. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
   4. Radiographic Inspection: ASTM E94.

D. Prepare test and inspection report.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
   1. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
   1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.
3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

   1. Set plates for structural members on wedges, shims, or setting nuts as required.
   2. Weld plate washers to top of baseplate.
   3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC 303 "Code of Standard Practice for Steel Buildings and Bridges."

D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
   1. Level and plumb individual members of structure.
   2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

E. Do not use thermal cutting during erection unless approved by the Engineer. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M.

F. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts" for type of bolt and type of joint specified.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
   1. Verify structural-steel materials and inspect steel frame joint details.
   2. Verify weld materials and inspect welds.
   3. Verify connection materials and inspect high-strength bolted connection.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Bolted Connections: Inspect and test bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts."
D. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M.

1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
   a. Liquid Penetrant Inspection: ASTM E165.
   b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
   c. Ultrasonic Inspection: ASTM E164.
   d. Radiographic Inspection: ASTM E94.

3.6 REPAIRS AND PROTECTION

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION
SECTION 220000 - GENERAL REQUIREMENTS FOR PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative and procedural requirements for all work. The administrative and procedural requirements included in this Section are to expand the requirements specified in Division 1.

1.2 SCOPE OF WORK

A. Provide all labor, material, equipment, and services necessary for and incidental to completion of all work as indicated on the Drawings and/or as specified herein. This includes all incidentals, equipment, appliances, services, hoisting, scaffolding, supports, sleeves, inserts, anchor bolts, tools, supervision, labor, consumable items, fees, licenses, etc., necessary to provide complete and workable systems.

1.3 DRAWING USE AND INTERPRETATION

A. Unless indicated by specific dimensions, drawings are meant to be diagrammatic. Exact equipment locations and routing of utilities shall be governed by field conditions and/or Owner’s Representative’s instructions.

B. All dimensions which relate to the building shall be taken as construction progresses. All errors incurred as result of the failure to check or verify dimensions, measurements, etc., shall be corrected.

C. The drawings show the general arrangement of utilities, equipment, and accessories. Drawings do not indicate all offsets, fittings, accessories, and changes in elevation, which may be necessary. Make all changes in equipment, locations, etc., to accommodate the work and to avoid obstacles at no increase in contract price. Provide offsets, fittings, and accessories as may be required to meet such conditions.

1.4 SPECIFICATION FORMAT AND CONTENT EXPLANATION

A. Specification Content: This Specification uses certain conventions regarding the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions are explained as follows:

1. Abbreviated Language: Language used in Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be interpolated as the sense requires. Singular words will be interpreted as plural and plural words interpreted as singular where applicable as the context of the Contract Documents indicates.

2. Streamlined Language: The Specifications generally use the imperative mood and streamlined language. Requirements expressed in the imperative mood are to be performed by the Contractor. At certain locations in the Text, subjective language is used for clarity to describe responsibilities that must be fulfilled indirectly by the Contractor or by others when so noted.
   a. The words “shall be” are implied where a colon (:) is used within a sentence or phrase.
1.5 **DEFINITIONS**

A. **General:** Basic Contract definitions are included in the conditions of the Contract.

B. **Indicated:** The term “indicated” refers to graphic representations, notes or schedules on the Drawings, or other Paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents. Where terms such as “shown,” “noted,” “scheduled,” and “specified” are used, it is to help the reader locate the reference; no limitation on location is intended.

C. **Directed:** Terms such as “directed,” “requested,” “authorized,” “selected,” “approved,” “required,” and “permitted” mean “directed by the Engineer,” “requested by the Engineer,” and similar phrases.

D. **Approved:** The term “approved,” where used in conjunction with the Engineer’s action on the Contractor’s submittals, applications, and requests, is limited to the Engineer’s duties and responsibilities as stated in the Conditions of the Contract.

E. **Regulations:** The term “Regulations” includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.

F. **Furnish:** The term “furnish” is used to mean “supply and deliver to the Project site, ready for unloading, unpacking, assembly, installation, and similar operations.”

G. **Install:** The term “install” is used to describe operations at project site including the actual “unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.”

H. **Provide:** The term “provide” means “to furnish and install, complete and ready for the intended use.”

I. **Installer:** An “installer” is the Contractor or an entity engaged by the Contractor, either as an employee, subcontractor, or contractor of lower tier for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

1. The term “experienced,” when used with the term “installer,” means having a minimum of five previous projects similar in size and scope to this Project, being familiar with the special requirements indicated, and having complied with requirements of the authority having jurisdiction.

2. **Trades:** Use of titles such as “carpentry” is not intended to imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as “carpenter.” It also does not imply that requirements specified apply exclusively to trades persons of the corresponding generic name.

3. **Assignment of Specialists:** Certain Sections of the Specifications require that specific construction activities shall be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and assignments are requirements over which the Contractor has no choice or option. Nevertheless, the ultimate responsibility of fulfilling Contract requirement remains with the Contractor.
   a. This requirement shall not be interpreted to conflict with enforcement of building codes and similar regulations governing the Work. It is also not intended to interfere with local trade union jurisdictional settlements and similar conventions.
J. The term “concealed”: embedded in masonry or other construction, installed behind wall furring, within partitions or hung ceilings (permanent or removable), in trenches, or in crawl spaces.

K. The term “exposed”: not installed underground or concealed. Equipment in rooms with exposed construction (i.e. mechanical rooms, electrical rooms, janitor’s closets, etc.) are classified as exposed.

L. The term “piping”: piping fittings, flanges, valves, controls, hangers, traps, drains, insulation and items necessary or required in connection with or relating thereto.

M. The “Project Site” is the space available to the contractor for performance of construction activities, either exclusively or in conjunction with other performing other work as part of the Project.

N. Testing Laboratories: A “testing laboratory” is an independent entity engaged to perform specific inspections or tests, either at the Project Site or elsewhere, and to report on and, if required, to interpret results of those inspections or tests.

1.6 COMPLETE SYSTEMS

A. General: Provide all materials as required for complete systems, including all parts obviously or reasonably incidental to a complete installation, whether specifically indicated or not. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation prior to Owner’s acceptance.

B. Systems: The systems specified and/or shown on the Drawings are for complete and workable systems. Any deviation from these systems due to a particular manufacturer’s requirements shall be made at no additional cost to the Owner.

1.7 CODES AND REGULATIONS

A. General: Comply with all governing federal, state, and local laws, ordinances, codes, rules, and regulations. Where the Contract Documents exceed these requirements, the Contract Documents shall govern. In no case shall work be installed contrary to or below minimum legal standards.

B. Utilities: Comply with all applicable rules, restrictions, and requirements of the utility companies serving the project site/facilities. Contractor shall be required to contact state regulated “call before you dig” service prior to any excavation work.

C. Non-Compliance: Should any work be performed which is found not to comply with any of the above codes and regulations, provide all work and pay all costs necessary to correct the deficiencies.

1.8 REFERENCE STANDARDS

A. All published standards of the following associations/organizations, as mandated by specific state standards, shall be followed and applied as a minimum.

AGA American Gas Assoc.
AIA The American Institute of Architects
AISC American Institute of Steel Construction
ANSI American National Standards Institute
ASME American Society of Mechanical Engineers
ASPE American Society of Plumbing Engineers
ASTM American Society for Testing and Materials
AWS American Welding Society
HI Hydronics Institute
B. Federal Government Agencies: Names and titles of federal government standard- or Specification-producing agencies are often abbreviated. The following acronyms or abbreviations referenced in the Contract Documents indicate names of standard- or Specification-producing agencies of the federal government. Names are subject to change and are believed, but are not assured, to be accurate and up-to-date as of the date of the Contract Documents.

EPA          Environmental Protection Agency
NIST         National Institute of Standards and Technology (U.S. Department of Commerce)
OSHA         Occupational Safety and Health Administration (U.S. Department of Labor)

C. Applicability of Standards: Except where the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents. Such standards are made a part of the Contract Documents by reference.

D. Copies of Standards: Each entity engaged in construction on the project is required to be familiar with industry standards applicable to that entity’s construction activity. Copies of applicable standards are not bound with the Contract Documents. Where copies of standards are needed for performance of a required construction activity, the contractor shall obtain copies directly from the publication source.

1.9 QUALITY ASSURANCE

A. Manufacturers’ Qualifications: Not less than five years experience in the actual production of the specified products.

B. Installers’ Qualifications:

1. Firm with not less than five years experience in the installation of mechanical systems and equipment similar in scope and complexity to those required for this Project, and having successfully completed at least ten comparable scale projects.

2. Painting, patching, carpentry and the like related to or required for Division 22 work shall be performed by craftsmen skilled in the appropriate trade.

3. All welding shall be performed by ASME certified welders.

1.10 INSPECTIONS

A. General: During and upon completion of the work, arrange and pay all associated costs for inspections of all work installed under this Contract, in accordance with the Conditions of the Contract.

B. Inspections Required: As per the laws and regulations of the local and/or state agencies having jurisdiction at the project site.

C. Inspection Agency: Approved by the local and/or state agencies having jurisdiction at the project site.
PART 2 - PRODUCTS

2.1 GENERAL

A. Where Specified: Materials and equipment shall be as specified in subsequent sections of the Project Manual and/or as indicated on the Drawings.

B. General: All materials and equipment to be new, clean, undamaged, and free of defects and corrosion.

C. Acceptable Products: The product will be acceptable only when that product complies with all requirements of the Contract Documents as determined by the Engineer.

D. Common Items: Where more than one of any specific item is required, all shall be of the same type and manufacturer.

E. Listing: All materials and equipment shall be Underwriters’ Laboratories (UL) or ETL SEMKO (ETL) listed and labeled, where UL or ETL standards and listings exist for the specified materials or equipment.

F. Special Tools: Provide all special tools needed for proper operation, adjustment and maintenance of equipment.

PART 3 - EXECUTION

3.1 GENERAL

A. The installation of all mechanical work shall be in accordance with the letter and intent of the Contract Documents, as determined by the Engineer.

B. Installation Requirements: All materials and equipment shall be installed as recommended by the respective manufacturers, by mechanics experienced and skilled in their particular trade, in a neat and workmanlike manner, in accordance with the standards of the trade, and so as not to void any warranty, UL or ETL listing.

3.2 DELIVERY STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original, unopened packaging, properly identified with manufacturer’s identification, and compliance labels.

B. Storage and Protection: Comply with all manufacturer’s written recommendations. Protect all equipment, materials and work from the weather elements, paint, mortar, construction debris and damage throughout duration of project.

C. Damaged Products: Do not install damaged products. Arrange for prompt replacement.

3.3 EXAMINATION

A. Conditions Verification: Examine the areas and conditions under which the work is to be performed. Identify and report any conditions detrimental to the proper and timely completion of the work to the Owner’s Representative.
3.4 DIMENSIONS
A. Building Dimensions: Exact locations of building elements shall be based on contractor’s field measurements.
B. Limiting Dimensions: Where equipment dimension and clearances are indicated on the Drawings, do not provide equipment larger than equipment dimensions or clearances specified.
C. Verify all dimensions by field measurements.

3.5 ROUGH-IN
A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.6 CUTTING AND PATCHING
A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
B. Perform cutting and patching of mechanical equipment and materials required to:
   1. Uncover Work to provide for installation of non-coordinated and/or improperly installed work.
   2. Remove and replace defective Work.
   3. Remove and replace Work not conforming to requirements of the Contract Documents.
   4. Remove samples of installed Work as specified for testing.
   5. Install equipment and materials in existing structures.
   6. Uncover and restore Work to provide for Engineer observation of concealed Work.
C. Cut, remove and legally dispose of equipment, components, and materials as indicated. Removal shall include all ancillary items associated with items removed. Remove all items made obsolete by the new work.
D. Protect the structure, furnishings, finishes, and adjacent materials not indicated to be removed.
E. Provide and maintain temporary dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
F. Patch surfaces and building components using new materials matching existing adjacent materials.

3.7 ADMINISTRATION AND SUPERVISION
A. The Contractor shall supervise the work and shall have at all times some competent person, approved by the Owner, following the work to receive instructions and to act with authority.

3.8 TESTING AND ADJUSTING
A. General: Provide testing equipment, materials, instruments, and personnel to perform all test procedures and adjustments required by other Division 22 Sections and/or deemed necessary by the Engineer to establish proper performance and installation of systems and equipment. All test instruments to be accurately calibrated and in good working order.
B. Scheduling: Schedule tests at least three days in advance, and so as to allow Engineer and Owner representative(s) to witness the test, unless directed otherwise. Do not schedule tests until the system installation is complete and fully operational, unless indicated or directed otherwise.

C. Correction/Replacement: After testing, correct any deficiencies, and replace materials and equipment shown to be defective or unable to perform at design or rated capacity. Retest without additional cost to the Owner or Contract. Submit finalization report indicating corrective measures taken, and satisfactory results of retest.

3.9 SYSTEMS DEMONSTRATION

A. Instruct the Owner’s representative(s) in the start-up, operation and maintenance of all systems and equipment in accordance with the Contract Documents.

3.10 CLEANING

A. General: Remove from the project site, all waste, rubbish, and construction debris weekly unless indicated otherwise. The premises shall be left clean and free of any debris and unused construction materials, prior to final acceptance.

B. Equipment: Remove all dust, dirt, debris, mortar, rust, and other foreign materials from the interior and exterior of all equipment and enclosures, and wipe down.

C. Utilities: Thoroughly clean all utilities, just prior to final inspection.

3.11 TOUCH-UP PAINTING

A. Touch-Up Painting: Restore and refinish to original condition, all surfaces of equipment scratched, marred and/or dented during shipping, handling, or installation. Remove all rust, and prime and paint as recommended by the manufacturer.

END OF SECTION
SECTION 220004 - COORDINATION WITH OTHER TRADES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This section describes the coordination and procedural requirements for Contractors.

B. Definitions:

1. Owners Representative - Engineer, Construction Manager, General Contractor, Clerk of the works or any stipulated Agent or Representative of the Owner.

2. GC - General Contractor

3. MC - Mechanical Contractor/Subcontractor

4. PC - Plumbing Contractor/Subcontractor

5. EC - Electrical Contractor/Subcontractor

6. SM - Sheet Metal Subcontractor

1.2 COMPLIANCE

A. Cost incurred including those of other contractors and/or Owner, due to non-compliance with this Section shall be the responsibility of the non-compliant contractor.

1.3 SUBMITTALS

A. Complete coordinated shop drawing shall be submitted in PDF format to the Engineer for their record by the MC. Submitted coordinated shop drawing shall include all signatures required by sign off procedure.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 COORDINATION

A. General: Sequence, coordinate and integrate the installation of all materials and equipment for efficient flow of work, in conjunction with the other trades. Review and become familiar with all of the Drawings and work of all the other trades. Report and resolve any discovered discrepancies and/or interferences prior to commencing work.

B. Cooperation: Cooperate with the other Contractors and individual disciplines for placement, anchorage and accomplishment of the work.

C. Chases, Slots, and Openings: Arrange for chases, slots, and openings during the progress of construction, as required to allow for installation of the work.

D. Supports and Sleeves: Coordinate the location installation of required supporting devices and sleeves to be set in concrete and other structural components, as they are constructed.
E. Right-Of-Way:

1. Adjust location of utilities, equipment, etc., to accommodate the work to prevent interferences, both anticipated and encountered.

2. Determine the exact route and location prior to fabrication.

3. Pitched piping has the right-of-way over utilities which do not pitch.

4. Furnish and install ancillary materials & equipment including but not limited to traps, air vents, drains, etc., as required to accommodate offsets, transitions and changes in direction.

F. Headroom: Install systems, materials, and equipment to maximize headroom unless noted otherwise.

G. Utility Connections: Coordinate connection with underground and overhead utility services. Comply with requirements of governing regulations, utility providers, and controlling agencies. Provide required connection for each service.

3.2 COORDINATED SHOP DRAWINGS

A. The coordination shop drawing process shall occur in the following manner:

1. The MC shall create 3/8” scale AutoCAD (2002 or newer) base plans which shall incorporate and coordinate with structural steel and ceiling system framing supports and show framing members on the shop drawings. This shall include existing building components not shown on Contract Documents.

2. The MC shall require the Sheet Metal Subcontractor to submit AutoCAD shop drawings, as expeditiously as possible, to the Engineer (through normal channels) for review and approval. The shop drawings shall incorporate all ductwork (including top and bottom of duct elevations at a maximum interval of 25 linear feet and at each elevation change), structural steel (building and misc. support steel), equipment and accessories as shown and/or specified in the contract documents.

3. All roof penetrations, wall and floor openings shall be coordinated with the structural steel Subcontractor, Supplier and/or Erector, through the Owner’s Representative. All conflicts with structural steel members shall be resolved through the Owner’s Representative.

4. After review and final approval of the sheet metal shop drawing by the Engineer, the sheet metal Subcontractor shall incorporate all required corrections, additions and modifications on the AutoCAD ductwork shop drawings.

5. The approved AutoCAD ductwork shop drawings shall be utilized for coordination with all other Contractors or Subcontractors whose involvement is mandated. The SM shall submit the AutoCAD ductwork shop drawings (hard copy and electronic files) to the PC to initiate the “coordination” process. The MC shall review the drawings for accuracy and completeness prior to distribution.

6. The MC shall forward, with transmittal, the ductwork shop drawings (hard copy and electronic files) to the PC for coordination of the plumbing work. The MC shall forward a copy of the transmittal to the Owner’s Representative.

7. The PC shall (upon receipt of drawings from the MC) superimpose his scope of work on the AutoCAD ductwork shop drawings illustrating all plumbing equipment, piping and hangers.
8. The PC shall include invert of pipes; elevations (top and bottom) and pipe sizes including insulation at a maximum of 25 foot intervals and at each elevation change.

9. Any conflicts between the plumbing and ductwork shall be clouded by the PC on the AutoCAD ductwork shop drawing file.

10. PC shall request coordination meeting to resolve the conflicts as clouded on the coordinated shop drawings. PC shall provide clouded shop drawing at the coordination meeting. All conflicts that arise between the plumbing and ductwork shall be resolved through and by the Owner’s Representative.

11. The PC and/or the SM shall correct and shall complete the AutoCAD drawings depicting all resolutions.

12. When it is ascertained that no conflicts exist between the ductwork and plumbing work, the PC shall forward the final ductwork/plumbing coordinated drawings (hard copy and electronic files) to the MC with transmittal, and provide the Owner’s Representative with a copy of the transmittal.

13. The MC shall (upon receipt of drawings from the PC) superimpose all heating and air conditioning piping, equipment, hangers, and insulation, including elevations (top and bottom) and pipe sizes (including insulation), on the AutoCAD drawings.

14. Any conflicts between the ductwork/plumbing/mechanical work shall be clouded by the MC on the AutoCAD shop drawing file.

15. MC shall request coordination meeting to resolve the conflicts as clouded on the coordinated shop drawings. MC shall provide clouded shop drawing at the coordination meeting. All conflicts that arise between the MC, SM and PC shall be resolved through and by the Owner’s Representative.

16. The MC, PC and SM shall correct and complete the AutoCAD drawings depicting all resolutions.

17. When it is ascertained that no conflicts exist between the MC, SM and PC, the MC shall forward the final ductwork/plumbing/mechanical coordinated drawings (hard copy and electronic files) to the EC with transmittal, and provide the Owner’s Representative with a copy of the transmittal.

18. The EC shall (upon receipt of drawings from the MC) superimpose all electrical equipment including but not limited to light fixtures, conduit and hangers on the AutoCAD drawings.

19. The EC shall include elevations of light fixtures, electrical conduit and conduit sizes.

20. Any conflicts with the ductwork/plumbing/mechanical/electrical work shall be clouded by the EC on the AutoCAD shop drawing file.

21. EC shall request coordination meeting to resolve any conflicts as clouded on the coordinated shop drawings. EC shall provide clouded coordinated shop drawing at the coordination meeting. All conflicts that arise between the EC, MC, PC and SM shall be resolved through and by the Owner’s Representative.

22. The EC and/or the SM, PC, MC shall correct and complete the AutoCAD drawings depicting all resolutions.
23. When it is ascertained that no conflicts exist between the EC, MC, PC, and SM, the EC shall forward the final ductwork/plumbing/mechanical/electrical/sprinkler coordination drawing to the MC with transmittal, and provide the Owner’s Representative with a copy of the transmittal.

24. Sign Off:
   
a. The MC shall provide the final coordinated shop drawing to the Engineer and the Owner’s Representative. The final coordinated shop drawing shall contain signatures from SM, PC, MC, and EC on each sheet.

   b. Upon completion of the coordination process by all Contractors and Subcontractors as described above, they shall sign off on all drawings in ink indicating company, name, date of sign-off, and signature of company representative.

   c. Each contractor signature shall certify that each Contractor has shown their respective work on the drawings and have resolved all points of conflict and interference with other Contractors and Subcontractors.

3.3 COORDINATION MEETINGS

A. During the coordination process, separate meetings apart from project meetings concerning the progress and schedules may be called by the Owner’s Representative when required or at the request of one or more of the coordinating Contractors.

   1. The Owner’s Representative shall contact the Contractors and make all required arrangements, e.g. time, place, etc.

   2. All Contractors shall place emphasis and importance on equipment purchases, so as to not delay approvals, shop drawings and the coordinated drawings.

3.4 SCHEDULE OF COORDINATED SHOP DRAWINGS

A. The MC and SM shall complete the ductwork shop drawings within two (2) weeks after award of contract (or authorization to proceed).

B. Turn-around time for each Contractor shall be two (2) weeks maximum.

3.5 “AS BUILT” DRAWINGS

A. At the completion of the project, “As Built” corrections shall be made to each AutoCAD drawing by each of the aforementioned Contractors and returned to the Owner’s Representative for the Owner’s permanent files and records. These “As Builts” do not remove the obligation of “As Builts” and record drawings as outlined under other sections of the specifications unless the Owner’s Representative elects to do so.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following basic materials and methods to complement other Division 22 Sections.

1. Piping installation instructions common to most piping systems
2. Dielectric fittings
3. Mechanical sleeve seals
4. Sleeves
5. Escutcheons
6. Fire Stopping
7. Identifying devices and labels
8. Grout
9. Installation requirements common to equipment specification sections
10. Touch-up painting
11. Removals
12. Repairs

B. Pipe, pipe fittings and joining materials and methods are specified in Division 22 piping system sections.

1.2 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, crawl spaces, and tunnels.

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

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

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

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

F. The following are industry abbreviations for plastic materials:
   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PVC: Polyvinyl chloride plastic.

G. Existing: Condition present prior to award of this contract.

1.3 SUBMITTALS

A. Product Data: For all materials specified within this section
B. Fire Rated Penetration Listing Details: Submit Underwriters Laboratory penetration listing details specific to the penetrations required by the project along with fire stopping material data.

C. Quality Control Submittals: Fire stopping certificates specified in Quality Assurance below.

1.4 QUALITY ASSURANCE

A. Fire Stopping: Fire stopping installer shall be certified by the fire stopping manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Protect piping, flanges, fittings, and piping specialties to prevent pipe end damage. Maintain end caps through shipping, storage, and handling.

B. Store plastic pipes in locations not subject to direct sunlight.

C. Protect all stored materials from moisture and dirt. Elevate above grade and support to prevent sagging and bending. Do not exceed structural capacity of floor, if stored inside.

1.6 SEQUENCING AND SCHEDULING

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

B. Install identifying devices before concealment.

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. Dielectric Components:
   a. Watts Water Technologies, Inc.
   b. Grinnell Corp.; Grinnell Supply Sales Co.
   c. Victaulic Co. of America.

2. Metal, Flexible Connectors:
   a. Engineered Flexible Products
   b. Flexicraft Industries.
   c. Grinnell Corp.; Grinnell Supply Sales Co.
   d. Mercer Rubber Co.
   e. Metraflex Co.

3. Mechanical Sleeve Seals:
   a. Calpico, Inc.
   b. Metraflex Co.
   c. Proco Products, Inc.
   d. Thunderline/Link-Seal.

4. Fire-Stopping Sealant:
   a. Dow Corning Corp.
   b. 3M Corp.
   c. Hilti Corp.
5. Pipe Escutcheons:
   c. Grinnell

6. Identifying Devices:
   a. Craftsmark Identification Systems
   b. Seton Identification Products
   c. W.H. Brady Company

2.2 DIELECTRIC FITTINGS

A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.

B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.

C. Insulating Material: Suitable for system fluid, pressure, and temperature.

D. Dielectric-Flange Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Dielectric flange kit materials shall be compatible with system fluid, temperature and pressure.

E. Dielectric Couplings: ARE NOT ALLOWED

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; and 300-psig (2070-kPa) minimum working pressure at 225° F (107° C). Coordinate end selection with piping system specifications.

2.3 MECHANICAL SLEEVE SEALS

A. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with stainless steel bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical isolation.

2.4 SLEEVES

A. General: The following materials are for wall, floor, slab and roof penetrations.

B. Pipe:
   1. Steel Sheet Metal: 0.0359-inch (0.9-mm) minimum thickness, galvanized, round tube closed with welded longitudinal joint.
   3. Cast Iron: Cast or fabricated pipe equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.
4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

2.5 ESCUTCHEONS

A. General: Manufactured wall, ceiling, and floor plates; deep-pattern type if required to conceal protruding fittings and sleeves.
   1. ID: Closely fit around pipe, tube, and insulation of insulated piping.
   2. OD: Completely cover opening.
   3. Stamped Steel: One piece, with set screw and chrome-plated finish.

2.6 FIRE STOPPING

A. UL listed material specific to the UL penetration listing detail.

2.7 IDENTIFYING DEVICES AND LABELS

A. Equipment Nameplates: Metal nameplate with operational data engraved or die-stamped; permanently fastened to equipment.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

B. Stick-on Pipe Markers: Manufacturer’s standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, complying with ASME A13.1.

C. Stick-on Flow Marker: Manufacturer’s standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, two inch (2”) wide band, color coded complying with ASME A13.1.

D. Rigid Pipe Markers: Manufacturer’s standard preprinted, color coded, rigid plastic with flow arrows and fluid medium designed to be applied to piping systems without the need of adhesives. For markers up to 6 inch, markers shall wrap completely around the pipe, and their own tension shall secure them in place. For markers over 6 inch, markers shall be provided with nylon ties to secure marker to piping system. Markers comply with ANSI/ASME A13.1.

E. Valve Tags: Stamped or engraved 0.032-inch- (0.8-mm-) thick, polished brass, 1-1/2-inches (40-mm) diameter, with 1/4-inch (6-mm) piping system abbreviation letters and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole and brass, wire-link or beaded chain; or brass S-hook fastener.

F. Access Panel Markers: 1/16-inch- (2-mm-) thick, engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed valve. Provide 1/8-inch (3-mm) center hole for attachment

G. Plastic Equipment Markers: ASME A13.1, color-coded, laminated plastic. Include lettering identifying name, equipment service, design capacity, pressure drop, entering and leaving conditions and RPM indicated on the contract documents. Size shall be 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; and 4-1/2 by 6 inches (115 by 150 mm) for equipment. Identifying names and/or abbreviations shall match those indicated on the contract documents.
2.8 GROUT

A. Non-shrink, Non-metallic Grout: ASTM C 1107, Grade B, post-hardening, volume-adjusting, dry, non-staining, non-corrosive, non-gaseous, hydraulic-cement grout recommended for interior and exterior applications. Design mix shall be 5000-psig (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. General: Install piping as described below, unless piping sections specify otherwise.

B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.

C. Install components with pressure and temperature ratings equal to or greater than system operating pressure and temperature.

D. Install piping free of sags and bends. Install fittings for changes in direction and branch connections. Install fittings, couplings, and accessories according to manufacturer’s written instructions.

E. Install piping at parallel and perpendicular to building walls. Diagonal runs are prohibited, unless otherwise indicated. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

F. In areas of exposed piping, install piping to maximize headroom. In areas with ceilings, install piping to maximize clearance between ceiling and pipe. Allow sufficient space for ceiling panel removal.

G. Install piping to allow application of insulation plus 1-inch (25-mm) clearance around insulation.

H. Install pipe escutcheons for pipe penetrations of walls, partitions, floors and ceilings.

I. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, ¾” ball valve, threaded nipple and chained cap.

J. Install line size manual shutoff valve at each connection to each piece of equipment.

K. Install piping so that accessories are accessible for operation, maintenance, repair and replacement.

L. Install piping with sufficient clearance to allow for expansion and contraction.

M. Sleeves are not required for core drilled holes through interior solid concrete walls and floors, above grade exterior solid concrete walls and existing underground solid concrete walls. Floors in mechanical equipment areas or other wet areas shall be provided with a sleeve with waterstop.

N. Install sleeves for pipes passing through walls, partitions, and slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. In floors with water stop extend cast-iron sleeve fittings below floor slab as required to secure clamping ring.

2. Build sleeves into new walls and slabs as walls and slabs are being constructed.
3. Install sleeves in non-fired rated assemblies large enough to provide 1/2-inch (12.7-mm) annular clear space between sleeve and pipe or pipe insulation.

4. Install sleeves in fire rated assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

O. Interior Wall and Floor Pipe Penetrations: Sleeves shall be steel pipe except steel sheet metal shall be used for gypsum wall penetrations.

P. Aboveground, Exterior-Wall, Pipe Penetrations:

Q. Underground, Exterior-Wall, Pipe Penetrations: Provide cast-iron or galvanized steel sleeves with integral waterstop, except for existing walls. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for annular clear space between pipe and sleeve for installing mechanical sleeve seals. Annular clear space shall be per mechanical sleeve seal manufacturer’s written recommendation. Assemble and install mechanical sleeve seals according to manufacturer’s written instructions.

R. Verify final equipment locations for roughing-in.

S. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections:
   1. Threaded Steel Pipe Joints: Thread pipe with tapered pipe threads in accordance with ANSI B2.1 and ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed. 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.
   3. Copper Pipe Joints: Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
   4. Gasket Materials: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.
   5. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
   6. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
   7. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following:
      a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
b. PVC Pressure Piping: ASTM D 2672.
c. PVC Nonpressure Piping: ASTM D 2855.

T. Piping Connections: Make connections according to the following, unless otherwise indicated:
   1. Remake leaking joints using new materials.
   2. Install unions, in piping 2-inch NPS (DN50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   3. Install flanges, in piping 2-1/2-inch NPS (DN65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.
C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting and without interference(s) to other installations.
D. Extend grease fittings to accessible locations.

3.3 FIRE STOPPING

A. Fire Stopping: At penetrations through fire rated walls, partitions, barriers, ceilings, roofs or floors, the fire rated integrity shall be maintained. Provide manufacturer’s standard fire-stopping sealant, with accessory materials, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

3.4 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on all piping of each system (insulated and un-insulated), including pipe sizes, fluid medium and direction of flow arrows.
   1. Interior, non-metal jacketed piping systems: Provide stick-on markers. Install flow marker 360 degrees at each end of each pipe marker.
   2. Interior metal jacketed and exterior piping systems: Provide rigid markers (for markers on piping over 6 inches provide nylon ties). Provide stick-on size marker attached to rigid marker.
   3. Markers shall be spaced at a maximum of 25-foot (7.5-m) intervals along each run. In addition to the 25 foot intervals, provide markers at the following locations:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for fixtures and terminal units.
c. Near locations where pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.
d. At access doors, manholes, and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.

B. Valve Tags:
   1. Install on all valves and control devices (factory and field installed), except check valves, plumbing fixture supply stops, faucets, and hose connections. List tagged valves in valve schedule.
   2. Provide framed valve schedule(s) where directed by owners representative.

C. Install plastic equipment marker on all equipment provided under this contract.

D. Provide additional mechanical identification materials and devices to supplement field or factory supplied nameplates that have become visually blocked by work of this or other Divisions.

E. Clean faces of identification devices and glass frames of valve charts.

3.5 TOUCH-UP PAINTING

A. Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 GROUTING

A. Install nonmetallic, non-shrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix and cure grout according to manufacturer’s written instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placing of grout.

E. Place grout to provide smooth bearing surface for equipment base.

F. Place grout, completely filling equipment bases.

G. Place grout around anchors.

3.7 REMOVALS

A. Disconnect and remove work where indicated on the contract documents in its entirety.

B. Removal: Remove indicated equipment, piping, ductwork, insulation and associated components from Project site and dispose of in a legal manner. Provide owner’s right of first refusal for all equipment removed.
C. Where work is indicated to be abandoned in place, cut and remove pipe or ductwork a minimum of 2 inches (50 mm) beyond the wall, floor, ceiling or roof. Patch surface to match existing finish of adjacent construction.

D. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

3.8 REPAIRS

A. If existing or new work is damaged or disturbed, remove damaged sections and install new products of equal capacity and quality.

END OF SECTION
SECTION 220519 - METERS AND GAGES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of meters and gages:
   1. Pressure gages and fittings.

1.2 SUBMITTALS

A. Product data for each type of meter and gage. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gage schedule showing manufacturer’s figure number, scale range, location, and accessories for each meter and gage.

B. Product certificates signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and products' compliance with specified requirements.

C. Maintenance data for each type of meter and gage.

1.3 QUALITY ASSURANCE

A. UL Compliance: Comply with applicable UL standards pertaining to meters and gages.

B. ASME and ISA Compliance: Comply with applicable portions of ASME and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Pressure Gages:

   4. Marshalltown Instruments, Inc.
   5. Trerice (H.O.) Co.
   6. Weiss Instruments, Inc.
   7. Weksler Instruments Corp.
   8. WIKA Instruments Corp.

B. Pressure Gage Accessories: Same as for pressure gages.

C. Test Plugs:

   1. MG Piping Products Co.
   2. Peterson Equipment Co., Inc.
   4. Trerice (H.O.) Co.
   5. Watts Regulator Co.
2.2 PRESSURE GAGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection.
B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.
C. Connector: Brass, 1/4-inch NPS.
D. Scale: White coated aluminum, with permanently etched markings.
E. Accuracy: Plus or minus 1 percent of range span.
F. Range: Conform to the following:
   1. Vacuum: 30 inches Hg to 15 psi.
   2. All fluids: 2 times operating pressure.

2.3 PRESSURE GAGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.
B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.4 TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.
B. Core Material: Conform to the following for fluid and temperature range:
   2. Air and Water, minus 30 to 275°F (minus 35 to 136°C): EPDM.
C. Test Kit: Provide test kit consisting of 1 pressure gage, gage adapter with probe, 2 bimetal dial thermometers, and carrying case.
D. Ranges of pressure gage and thermometers shall be approximately 2 times systems operating conditions.

PART 3 - EXECUTION

3.1 INSTALLATION OF PRESSURE GAGES

A. Install pressure gages in piping tee with pressure gage valve, located on pipe at most readable position.
B. Install in the following locations, and elsewhere as indicated:
   1. At discharge of each pressure-reducing valve.
   2. At building water service entrance.
C. Pressure Gage Needle Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.
3.2 INSTALLATION OF TEST PLUGS

A. Test Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.3 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer’s touch-up paint.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other sections. The drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install meters and gages piping adjacent to machine to allow servicing and maintaining of machine.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: This section includes general duty valves common to most mechanical piping systems. Special purpose valves are specified in individual piping system specifications.

1.2 SUBMITTALS

A. Product Data: Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances.

B. Valve Schedule: Valve schedule indicating manufacturer’s figure number, size, location, and valve features for each required valve, and installation instructions.

1.3 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.4 STORAGE AND HANDLING

A. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

B. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the manufacturers listed in valve schedule.

B. Provide valves of same manufacturer throughout where possible. Manufacturer’s name, valve size, and pressure rating shall be clearly marked on outside of body.

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.

1. Non-rising stem valves may be used where headroom prevents full extension of rising stems.
B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:
   1. Handwheels, fastened to valve stem, for valves other than quarter turn.
   2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves.
   3. Chain-wheel operators, for valves 2-1/2-inch and larger, install 72 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.

2.3 BALL VALVES

A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 600 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable “Teflon” or “TFE” seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water.

B. Ball Valves, 1-1/4-Inch to 2 Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, full port, stainless steel ball, replaceable “Teflon” or “TFE” seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water and low-pressure steam.

C. Ball Valves, 2-1/2-Inch and Up: Rated for 150 psi saturated steam pressure, 400 psi WDG pressure; 3 piece construction; with carbon steel body conforming to ASTM-A216 WCB, full port, stainless steel ball, replaceable “Teflon” or “TFE” seats and seals, blowout proof stem, and vinyl covered steel handle - flanged ends.

2.4 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks for sizes 2 through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. Provide full lug type body; drilled and tapped valves for dead-end service unless otherwise specified.
PART 3 - EXECUTION

3.1 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:
   1. Copper Tube Size, 2-Inch and Smaller: Threaded ends.
   2. Steel Pipe Sizes, 2-Inch and Smaller: threaded end.

3.2 VALVE INSTALLATIONS

A. General Application: Use ball and butterfly valves for shut-off duty. Refer to piping system specification sections for specific valve applications and arrangements.

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

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install three-valve bypass around each pressure reducing valve.

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

F. Install valves in a position to allow full stem movement.

G. Install access doors in ceilings or walls as required in the types and sizes to accommodate easy valve access and construction (sheet rock, etc. and fire rating).

3.3 FLANGED CONNECTIONS

A. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.4 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.5 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.
3.6 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>BALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Cold Water</td>
<td>150</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>BUTTERFLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Cold Water</td>
<td>200</td>
</tr>
</tbody>
</table>

3.7 VALVE SCHEDULE

A. Ball Valves - 1 Inch and Smaller:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>THREADED ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conbraco (Apollo)</td>
<td>70-100</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>BA-100</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-585-70</td>
</tr>
</tbody>
</table>

B. Ball Valves - 1-1/4 Inch to 2 Inch:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>THREADED ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conbraco (Apollo)</td>
<td>82-100</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>300S</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-590-Y</td>
</tr>
</tbody>
</table>

1. For ball valves 2-1/2" and up - flanged carbon steel with stainless steel trim - Milwaukee - F90CS 150R-02 or approved equal.

C. Butterfly Valves - 2-1/2 Inch and Larger: Wafer type.

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>CW-223E-B</td>
<td>CW-323E-B</td>
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<tr>
<td>Nibco</td>
<td>WD-20103</td>
<td>WD-20105</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-03-111-11</td>
<td>BF-04-111-12</td>
</tr>
</tbody>
</table>

Note: Wafer type valves are to be used only when specifically indicated as approved for use, otherwise use lug type as standard.

1. The following are model numbers for lug-type, with nickel-plated ductile-iron disc:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
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<tbody>
<tr>
<td>Milwaukee</td>
<td>ML-222-E</td>
<td>ML-322-E</td>
</tr>
<tr>
<td>Nibco</td>
<td>LD-20103</td>
<td>LD-20105</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-03-111-11</td>
<td>BF-03-111-12</td>
</tr>
</tbody>
</table>

2. The following are model numbers for lug-type, with aluminum-bronze disc:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>ML-223-E</td>
<td>ML-323-E</td>
</tr>
<tr>
<td>Nibco</td>
<td>LD-20003</td>
<td>LD-20005</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-03-121-11</td>
<td>BF-03-121-12</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes pipe, duct, and equipment insulation.

1.2 DEFINITIONS
A. Hot Surfaces: Normal operating temperatures of 100°F or higher.
B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.
C. Cold Surfaces: Normal operating temperatures less than 75°F.
D. Thermal Resistivity: "r-values" represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees °F between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.
E. Density: Is expressed in lb/sq.ft.

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 mechanical insulation identifying k-value, thickness, and accessories.
C. Manufacturer’s installation instructions.
D. Schedule of materials and thickness for each piece of equipment.

1.4 QUALITY ASSURANCE
A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E 84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.
   1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
   2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

1.5 SEQUENCING AND SCHEDULING
A. Schedule insulation application after testing of piping systems.
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 one of the following:

1. Glass Fiber:
   a. CertainTeed Corporation.
   b. Knauf Fiberglass GmbH.
   c. Manville.
   d. Owens-Corning Fiberglas Corporation.
   e. USG Interiors, Inc. - Thermafiber Division.

2. Vinyl-Acrylic Mastic:
   a. Childers Products Co.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.


C. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, jacketed.

1. Thermal Conductivity: 0.27 average maximum at 75ºF mean temperature.
2. Density: 10 average maximum.

D. Adhesive: Produced under the UL Classification and Follow-up service.

1. Type: Non-flammable, solvent-based.
2. Service Temperature Range: Minus 20 to 180ºF.

E. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.

2.3 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer.

B. Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:

1. Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
2. Class 2, Grade A for bonding glass fiber insulation to metal surfaces.

2.4 JACKETS

A. General: ASTM C 921, Type 1, except as otherwise indicated.

1. Water Vapor Permeance: 0.02 perm maximum, when tested according to ASTM E 96.
2. Puncture Resistance: 50 beach units minimum, when tested according to ASTM D 781.

C. Aluminum Jacket: ASTM B 209, 3003 Alloy, H-14 temper, roll stock ready for shop or field cutting and forming to indicate sizes or factory cut and rolled to indicated sizes.

1. Finish and Thickness: Stucco embossed finish, 0.016 inch thick.
3. Elbows: Preformed 45-degree and 90-degree, short- and long-radius elbows, same material, finish, and thickness as jacket.

2.5 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4-inch wide, in one of the following materials compatible with jacket:

1. Stainless Steel: Type 304, 0.020 inch thick.
2. Galvanized Steel: 0.005 inch thick.
3. Aluminum: 0.007 inch thick.
4. Brass: 0.01 inch thick.
5. Nickel-Copper Alloy: 0.005 inch thick.

B. Wire: 14-gage nickel copper alloy, 16-gage, soft-annealed stainless steel, or 16-gage, soft-annealed galvanized steel.

C. Corner Angles: 28-gage, 1-inch by 1-inch aluminum, adhered to 2-inch by 2-inch kraft paper.

D. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.

2.6 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.

1. Water Vapor Permeance: 0.08 perm maximum.
2. Temperature Range: Minus 20 to 180°F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.

1. Water Vapor Permeance: 0.02 perm maximum.
2. Temperature Range: Minus 50 to 250°F.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.
3.2 INSTALLATION, GENERAL

A. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each mechanical system.

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

C. Install vapor barriers on insulated pipes and equipment having surface operating temperatures below 60°F.

D. Install insulation only after systems to be insulated have been tested and approved.

E. Apply insulation material, accessories, and finishes according to the manufacturer’s printed instructions.

F. Install insulation with smooth, straight, and even surfaces.

G. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

H. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

I. Seal Ends: Except for flexible elastomeric insulation, taper ends at 45 degree angle and seal with lagging adhesive. Cut ends of flexible elastomeric cellular insulation square and seal with adhesive.

J. Apply adhesives and coatings at manufacturer’s recommended coverage-per-gallon rate.

K. Keep insulation materials dry during application and finishing.

L. Install board and block materials with a minimum dimension of 12 inches and a maximum dimension of 48 inches.

M. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors for pipes.
2. Vibration control devices.
3. Testing laboratory labels and stamps.
5. Fire protection piping systems.
7. Piping specialties including air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.

B. Stagger joints on double layers of insulation.
C. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.

D. Apply insulation with a minimum number of joints.

E. Apply insulation with integral jackets as follows:
   1. Pull jacket tight and smooth.
   2. Cover circumferential joints with butt strips, at least 3-inches wide, and of same material as insulation jacket. Secure with adhesive along both edges of butt strip and space 4 inches on center.
   3. Longitudinal Seams: Overlap seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
   4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints and at ends butt to flanges, unions, valves, and fittings.
   5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.
   6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere and seal. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

F. Exterior Wall Penetrations: For penetrations of below grade exterior walls, extend metal jacket for exterior insulation through penetration to a point 2 inches from interior surface of wall inside the building. Seal ends of metal jacket with vapor barrier coating. Secure metal jacket ends with metal band. At point where insulation metal jacket contacts mechanical sleeve seal, insert cellular glass preformed pipe insulation to allow sleeve seal tightening against metal jacket. Tighten and seal sleeve to jacket to form a watertight seal.

G. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer. Refer to Division 7.

H. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer. Refer to Division 7 for firestopping and fire-resistant joint sealers.

I. Floor Penetrations: Terminate insulation underside of floor assembly and at floor support at top of floor.

J. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight. Bond with adhesive.
   1. Use same material and thickness as adjacent pipe insulation.
   2. Overlap nesting insulation by 2 inches or 1-pipe diameter, which ever is greater.
3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.

4. Insulate elbows and tees smaller than 3-inches pipe size with premolded insulation.

5. Insulate elbows and tees 3 inches and larger with premolded insulation or insulation material segments. Use at least 3 segments for each elbow.

6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

K. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install saddles, shields, and inserts as specified in “Hangers, Supports and Anchors.” For cold surface piping, extend insulation anchor legs a minimum of 12 inches and taper and seal insulation ends.

1. Inserts and Shields: Cover hanger inserts and shields with jacket material matching adjacent pipe insulation.

2. Special Treatment at Hanger Locations: At hanger locations on insulated piping 2” and larger, install high density rigid fiber glass pipe support blocks. On piping up to and including 5”, install one block at each hanger, directly on the bottom of the pipe. For 6”, 8”, and 10” piping, install two (2) blocks at each hanger oriented 30 degrees from each side of the bottom. For piping 12” and larger, orientate blocks at both the 30 degrees positions and directly on the bottom. Install blocks inside cut out section of pipe insulation, being careful not to damage the vapor barrier jacketing. Any jacketing so damaged should be repaired with matching vapor barrier tape.

3.4 BELOW GROUND PIPE INSULATION INSTALLATION

A. General: The following are additional requirements for insulation applied to piping installed below ground.

B. Coat bore surfaces of insulation materials with insulating cement of type recommended by insulation manufacturer. Apply enough cement to fill surface cells. Do not use adhesives for this coating.

C. Secure insulation with a minimum of 2 stainless-steel bands for each section of insulation.

D. Terminate insulation at anchor blocks.

E. Apply insulation continuously through sleeves and manholes, except as specified above for exterior wall penetrations.

F. Finishing: Apply 3 coats of asphaltic mastic to a finish thickness of 3/16 inch over insulation materials. Apply 10 x 10 mesh glass cloth between coats. Overlap edges of glass cloth by 2 inches.

3.5 GLASS FIBER PIPE INSULATION INSTALLATION

A. Bond insulation to pipe with lagging adhesive.

B. Seal exposed ends with lagging adhesive.

C. Seal seams and joints with vapor barrier compound.
3.6 FLEXIBLE ELASTOMERIC CELLULAR EQUIPMENT INSULATION INSTALLATION

A. Install sheets of the largest manageable size.
B. Apply full coverage of adhesive to the surfaces of the equipment and to the insulation.
C. Butt insulation joints firmly together and apply adhesive to insulation edges at joints.

3.7 JACKETS

A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 1-1/2-inch laps at longitudinal joints and 3-inch-wide butt strips at end joints.
   1. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.
B. Interior Exposed Insulation: Install continuous aluminum jackets.
C. Exterior Exposed Insulation: Install continuous aluminum jackets and seal all joints and seams with waterproof sealant.
D. Install metal jacket with 2-inch overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 12 inches on center and at butt joints.

3.8 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules at the end of this Section.
B. Interior Piping Systems: Unless otherwise indicated, insulate the following piping systems:
   1. Domestic cold water.
   2. Cooling coil condensate.
C. Exterior Piping Systems: Unless otherwise indicated, insulate the following piping systems:
   1. Domestic cold water.

3.9 PIPE INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:
B. Domestic Cold Water and Condensate Drains (Interior): 1/2-inch-thick glass fiber insulation. Field-applied jacket is not required.

<table>
<thead>
<tr>
<th>Pipe Sizes (NPS)</th>
<th>Materials</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Glass Fiber</td>
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</tr>
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</table>

END OF SECTION
SECTION 221116 - WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes potable water distribution, including cold- and hot-water supply and hot-water recirculation to a point 5 feet outside the building.

1.2 SUBMITTALS
A. Product data for all products specified in this section.
B. Water samples, test results, and reports specified in “Field Quality Control” and “Cleaning” Articles.
C. Coordination drawings, drawn accurately to scale and coordinating penetrations.

1.3 SYSTEM PERFORMANCE REQUIREMENTS
A. Provide piping system with the following minimum working pressure ratings, except where indicated otherwise:

1.4 QUALITY ASSURANCE
A. Comply with the provisions of ASME B31.9 “Building Services Piping” for materials, products, and installation.
B. Provide listing/approval stamp, label, or other marking on piping made to specified standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. All products specified in this section shall be manufactured in the USA and/or Canada.

2.2 PIPES AND TUBES
A. General: The application of the following pipe, tube, and fitting materials and joining methods required for plumbing piping systems are indicated in Part 3 Article “Pipe and Fittings Applications.”
B. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
D. Ductile-Iron Pipe: AWWA C151, Classes 50 and 51, mechanical joint and push-on joint, with AWWA C104 cement-mortar lining.
E. Flanged Ductile-Iron Pipe: AWWA C115, ductile-iron barrel, Class 150 or 300 iron-alloy threaded flanges, with AWWA C104 cement-mortar lining.
2.3 PIPE FITTINGS AND TUBE FITTINGS

A. Wrought-Copper, Solder-Joint Pressure Fittings: ASME B16.22.


C. Bronze Flanges: ASME B16.24, Classes 150 and 300.

D. Copper Unions: ASME B16.18, cast-copper-alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, and solder-joint, threaded, or solder-joint and threaded ends.


G. Cast-Iron Threaded Flanges: ASME B16.1, Classes 125 and 300.

2.4 JOINING MATERIALS

A. Solder, brazing, and welding filler metals are specified in other Sections.

B. Ductile-Iron Pipe and Ductile-Iron or Cast-Iron Fittings: The following materials apply:


   2. Mechanical Joints: AWWA C111 ductile-iron or gray-iron glands, high-strength steel bolts and nuts, and rubber gaskets.

   3. Flanged Joints: AWWA C115 ductile-iron or gray-iron pipe flanges, rubber gaskets, and high-strength steel bolts and nuts.

2.5 VALVES

A. Refer to other Sections.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavation, trenching, and backfilling are specified elsewhere.

3.2 PIPE AND FITTINGS APPLICATIONS

A. General: Use pipe, tube, fittings, and joining methods for piping systems according to the following applications.
B. Water Distribution Piping Below Ground: Use the following:

1. 3 to 12 Inches: Ductile-iron pipe, ductile-iron or gray-iron fittings, rubber gaskets, and push-on or mechanical joints.
2. 3 Inches and smaller: Soft copper tube, Type K, cast-copper-alloy solder-joint pressure fittings and soldered joints with Alloy Sn95 solder.

C. Water Distribution Piping Above Ground: Use the following:

1. 6 Inches and Smaller: Hard copper tube, Type L; wrought-copper or cast-copper-alloy pressure fittings; copper unions; bronze flanges; and solder joints with Alloy Sn95 solder.

3.3 VALVE APPLICATIONS

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

1. Shutoff Duty: Use gate, ball, or butterfly valves.
2. Throttling Duty: Use globe, ball, or butterfly valves.

3.4 PIPING INSTALLATION, GENERAL

A. Basic piping installation requirements are specified in other Sections.

3.5 WATER DISTRIBUTION PIPING INSTALLATION

A. Install piping with 1/32-inch-per-foot (1/4 percent) slope downward toward drain.

3.6 JOINT CONSTRUCTION

A. Basic piping joint construction is specified in other Sections.

3.7 INSTALLATION OF VALVES

A. Sectional Valves: Install sectional valves close to main on each branch and riser serving 2 or more plumbing fixtures or equipment connections and where indicated.

B. Shutoff Valves: Install shutoff valves on inlet to each plumbing equipment item, on each supply to each plumbing fixture not having stops on supplies, and elsewhere as indicated.

C. Drain Valves: Install drain valves, specified in other Sections, on each plumbing equipment item located to drain equipment for service and repair. Install drain valve at base of each riser, at low points of horizontal runs, and where required to drain water distribution piping system.

1. Install hose-end drain valves at low points in water mains, risers, and branches.
2. Install stop and waste drain valves where indicated.

D. Check Valves: Install check valve on discharge side of each pump and elsewhere as indicated.

E. Balance Valves: Install valve in each hot-water circulating loop, discharge side of each pump, and elsewhere as indicated.
3.8 HANGERS AND SUPPORTS INSTALLATION

A. Hanger, support and anchor devices are specified in other Sections.

3.9 CONNECTIONS

A. Supply Runouts to Fixtures: Install hot- and cold-water supply piping runouts of sizes indicated, but not smaller than required by plumbing code to fixtures.

B. Mechanical Equipment Connections: Connect cold-water supply piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection. Use flanges instead of unions for connections 2-1/2 inches and larger.

3.10 FIELD QUALITY CONTROL

A. Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.

2. During progress of the installation, notify the plumbing official having jurisdiction at least 24 hours prior to time inspection must be made. Perform tests specified below in presence of the plumbing official.
   a. Roughing-In Inspection: Arrange for inspection of piping system before concealed or closed-in after system roughing-in and prior to setting fixtures.
   b. Final Inspection: Arrange for final inspection by plumbing official to observe tests specified below and to ensure compliance with requirements of plumbing code.

3. Reinspections: When a plumbing official finds that piping system will not pass test or inspection, make required corrections and arrange for reinspection by the plumbing official.

4. Reports: Prepare inspection reports signed by plumbing official.

B. Test water distribution piping as follows:

1. Test for leaks and defects in new water distribution piping systems and parts of existing systems 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 system tested.

2. Leave uncovered and unconcealed in new, altered, extended, or replaced water distribution piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved for testing.

3. Cap and subject the piping system to a static water pressure of 50 psig above the operating pressure without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.

4. Repair leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained.

5. Prepare reports for tests and required corrective action.
3.11 CLEANING

A. Clean and disinfect water distribution piping as follows:

1. Purge new potable water distribution piping systems and parts of existing potable water systems that have been altered, extended, or repaired prior to use.

2. Use purging and disinfecting procedure prescribed by authority having jurisdiction or, if a method is not prescribed by that authority, the procedure described in either AWWA C651 or AWWA C652 or as described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill system or part thereof with water/chlorine solution containing at least 50 parts per million of chlorine. Isolate (valve off) and allow to stand for 24 hours.
   c. Drain system or part thereof of previous solution and refill with water/chlorine solution containing at least 200 parts per million of chlorine. Isolate and allow to stand for 3 hours.
   d. Flush system with clean, potable water until the chlorine level matches the level in clean potable water source.
   e. Submit water samples in sterile bottles to authority having jurisdiction. Repeat procedure if biological examination made by the authority shows evidence of contamination.

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

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

3.12 COMMISSIONING

A. Fill water systems. Check compression tanks to determine that they are not air bound and that system is completely full of water.

B. Before operating systems, perform these steps:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to full open position.

3. Open throttling valves to proper setting.

4. Remove plugs used during testing of piping systems and plugs used for temporary sealing of piping during installation.

5. Remove, clean, and reinstall strainer screens. Replace damaged strainer screens. Close drain valves and replace drain plugs.

C. Check plumbing equipment and verify proper settings, adjustments, and operation.

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

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes plumbing specialties for water distribution systems; soil, waste, and vent systems; and storm drainage systems.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working pressure ratings, except where otherwise indicated:


1.3 SUBMITTALS

A. Submit product data for all materials specified within this Section, including rated capacities of selected models and weights (shipping, installation, and operation). Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following plumbing specialty products.

B. Maintenance data for all materials specified within this Section for inclusion in Operating and Maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with ASME B31.9, “Building Services Piping,” for materials, products, and installation.


C. Listing and Labeling: Provide equipment that is listed and labeled.

1. The Terms “Listed” and “Labeled” As defined in the “National Electrical Code,” Article 100.

D. Design Concept: The Drawings indicate capacities, sizes, and dimensional requirements of system components. Components having equal performance characteristics that deviate from the indicated size and dimensions may be considered, provided deviations do not change the design concept or intended performance. The burden of proof for equality of products is on the Contractor.

1.5 EXTRA MATERIALS

A. Deliver extra materials to Owner. Furnish extra materials matching products installed as described below. Package them with protective covering for storage and identify with labels clearly describing contents.

B. Operating Keys (Handles): Furnish 2 extra keys for each key-operated hose bibb and hydrant installed.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Backflow Preventers:
   a. Conbraco Industries, Inc.
   b. Febco.
   c. Watts Regulator Co.
   d. Wilkins Regulator Div., Zurn Industries, Inc.

2. Water Pressure Regulators:
   a. Conbraco Industries, Inc.
   b. Spence Engineering Co., Inc.
   c. Watts Regulator Co.
   d. Wilkins Regulator Div., Zurn Industries, Inc.

3. Sleeve Penetration Systems:
   a. Proset Systems, Inc.

2.2 BACKFLOW PREVENTERS

A. General: ASSE Standard, backflow preventers, of size indicated for maximum flow rate indicated and maximum pressure loss indicated.

1. Working Pressure: 150 psig minimum except where indicated otherwise.

2. 2 Inches and Smaller: Bronze body with threaded ends.

3. 2-1/2 Inches and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.


5. Exterior Finish: Manufacturer’s standard finish unless noted otherwise.

6. Strainer on inlet, where strainer is indicated.

B. Reduced-Pressure-Principle Backflow Preventer: ASSE 1013, consisting of (OS&Y) gate valves on inlet and outlet and strainer on inlet. Include test cocks and pressure-differential relief valve having ASME A112.1.2 air-gap fitting located between 2 positive-seating check valves for continuous pressure application.

1. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.

2.3 WATER PRESSURE REGULATORS

A. General: ASSE 1003, water pressure regulators, rated for initial working pressure of 150 psig minimum, of size, flow rate, and inlet and outlet pressures indicated. Include integral factory-installed or separate field-installed Y type strainer.

1. 2 Inches and Smaller: Bronze body with threaded ends.

2. 2-1/2 Inches and Larger: Bronze or cast-iron body with flanged ends.
4. Exterior Finish: Polished chrome plate when used in chrome plated piping system.

B. Single-seated, direct-operated, integral-bypass type.

C. Pilot-operated type, single- or double-seated, cast-iron body main valve, with bronze-body pilot valve.

2.4 MISCELLANEOUS PIPING SPECIALTIES

A. Piping specialties such as escutcheons, dielectric fittings, sleeves, and sleeve seals are specified in other Sections.

B. Strainers: Y pattern, except where otherwise indicated, full size of connecting piping. Include Type 304 stainless-steel screens with 3/64-inch perforations except where other screens are indicated.

1. Pressure Rating: 125-psig minimum steam working pressure except where otherwise indicated.

2. Sizes 2 Inches and Smaller: Bronze body, with female threaded ends.

3. Sizes 2-1/2 Inches and Larger: Cast-iron body, with interior FDA-approved epoxy coating and flanged ends.

4. Y-Type Strainers: Screwed screen retainer with centered blowdown.
   a. Drain: Factory- or field-installed, hose-end drain valve.

C. Hose-End, Drain Valves: 3/4-inch ball valve, rated for 400 psig WOG. Include 2-piece bronze body conforming to ASTM B 62, standard port, chrome-plated brass ball, replaceable “TFE” seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Solder-joint or threaded.

2. Outlet: Short-threaded nipple with ASME B1.20.7 garden-hose thread and cap.

2.5 SLEEVE PENETRATION SYSTEMS

A. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.


PART 3 - EXECUTION

3.1 PIPING SPECIALTY INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated, at each water supply connection to mechanical equipment and systems, and to other equipment and systems as indicated. Comply with plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Install air-gap fitting on units having atmospheric vent connection and pipe relief outlet drain to nearest floor drain. Do not install bypass around backflow preventer.
B. Install pressure-regulating valves with inlet and outlet shutoff valves and balance cock bypass. Install pressure gage on valve outlet and install valved bypass where indicated.

C. Install strainers on supply side of each control valve, pressure-regulating valve, and solenoid valve, and where indicated.

3.2 CONNECTIONS

A. Supply Runouts: Install cold-water supply piping for makeup water runouts to HVAC system of sizes indicated, but not smaller than required by plumbing code.

3.3 COMMISSIONING

A. Preparation: Perform the following checks before start-up:

1. Systems tests are complete.
2. Damaged and defective specialties and accessories have been replaced or repaired.
3. There is clear space for servicing of specialties.

B. Before operating systems, perform these steps:

1. Close drain valves, hydrants, and hose bibbs.
2. Open valves to full open position.
3. Remove and clean strainers.
4. Verify drainage and vent piping are clear of obstructions. Flush with water until clear.

C. Starting Procedures: Follow manufacturer’s written procedures. If no procedures are prescribed by manufacturer, proceed as follows:

3.4 ADJUSTING

A. Adjust operation and correct deficiencies discovered during commissioning.

3.5 DEMONSTRATION

A. Train Owner’s maintenance personnel on procedures related to startup and servicing of interceptors.

3.6 PROTECTION

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

B. Place plugs in ends of uncompleted piping at end of day or when work stops.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping, specialties, and accessories for natural gas systems.

B. Approximately values of natural gas that will be supplied for these systems are the following:

2. Specific Gravity: 0.6.

1.2 DEFINITIONS

A. Low-Pressure Natural Gas Piping System: Operating at pressure of 2.0 psig or less.

B. Medium-Pressure Natural Gas Piping System: Operating at pressure greater than 10 psig, but not greater than 2 psig.

C. High-Pressure Natural Gas Piping System: Operating at pressure greater than 20.0 psig, but not greater than 5 psig.

D. Natural Gas Service: Operating at pressure indicated.

E. Gas Main or Distribution Main: Piping to convey gas to individual gas services or other gas mains.

F. Gas Service: Pipe from the gas main or other source to gas point of delivery for the building being served. Piping includes gas service piping, gas valve, service pressure regulator, meter bar or meter support, and gas meter.

G. Gas Delivery Point: Outlet of gas meter or service pressure regulator, or when no gas meter is provided, the gas service valve.

H. Gas Piping System: Pipe within the building that conveys gas from point of delivery to points of usage. Piping includes dielectric fitting and gas valve immediately downstream from point of delivery.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure Ratings: Except where otherwise indicated, the following are minimum pressure requirements.

1. Low-Pressure Natural Gas Piping Systems: 2 psig.

1.4 SUBMITTALS

A. Product data for each type of natural gas specialty and special-duty valve. Include pressure rating in psig, rated capacity in cu. ft. per hour (CFH), and settings of selected models.
B. Coordination drawings for natural gas piping systems, including required clearances and relationship to other services that serve the same work areas.

C. Maintenance data for natural gas special ties and special-duty valves for inclusion in Operating and Maintenance Manuals.

D. Test reports specified in “Field Quality Control” Article in Part 3.

1.5 QUALITY ASSURANCE
A. Comply with NFPA 54 “National Fuel Gas Code” for gas piping materials and components; installations; and inspection, testing, and purging. Where applicable, also comply with natural gas utility company’s standards.

B. Comply with NFPA 70 “National Electrical Code” for electrical connections between wiring and electrically operated control devices.

C. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.

D. Listing and Labeling: Provide equipment and accessories that are listed and labeled.
   1. Terms “Listed” and “Labeled”: As defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

E. Product Options: Natural gas systems equipment, specialties, and accessories are based on specific types, manufacturers, and models indicated. Equipment and other components having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions, operation, and other characteristics do not change design concept or intended performance as judged by the Engineer. The burden of proof of equality of products is on the Contractor.

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

1.7 SEQUENCING AND SCHEDULING
A. Notification of Interruption of Service: Notify each affected user when gas supply will be turned off.

B. Work Interruptions: Leave gas systems in a safe condition when interruptions in work occur while repairs or alterations are being made to existing gas piping systems.

PART 2 - PRODUCTS
2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Gas Meters:
      a. American Meter Co.
c. Equimeter, Inc., A BTR Co.
d. Lancaster by National Meter Parts, Inc.
e. Schlumberger Industries, Gas Div.

2. Meter Bars:
   a. Lancaster by National Meter Parts, Inc.
   b. A.Y. McDonald Mfg. Co.
   c. Rockford-Eclipse Div., Eclipse, Inc.
   d. Schlumberger Industries, Gas Div.

3. Gas Pressure Regulators:
   a. American Meter Co.
   c. Fisher Controls.
   e. Jordan Valve Div., Richards Industries, Inc.
   f. Lancaster by National Meter Parts, Inc.
   g. Maxitrol Co.
   h. Schlumberger Industries, Gas Div.

4. Low-Pressure Gas Stops:
   a. Hammond Valve Corp.
   b. Jomar International, Ltd.
   c. Lancaster by National Meter Parts, Inc.
   d. A.Y. McDonald Mfg. Co.
   e. Rockford-Eclipse Div., Eclipse, Inc.

5. Gas Valves, 2 Inches and Smaller:
   a. Homestead by Olson Technologies, Inc.
   b. Lancaster by National Meter Parts, Inc.
   c. Lunkenheimer Co.
   d. A.Y. McDonald Mfg. Co.
   e. Milliken Valve Co., Inc.
   g. Mueller Steam Specialty Div., Core Industries, Inc.
   h. Nordstrum Valves, Inc.
   i. Resun by J.M. Huber Corp., Equipment Div.
   j. Rockford-Eclipse Div., Eclipse, Inc.

6. Gas Valves, 2-1/2 Inches and Larger:
   a. Homestead by Olson Technologies, Inc.
   b. Milliken Valve Co., Inc.
   c. Mueller Steam Specialty Div., Core Industries, Inc.
   d. Nordstrum Valves, Inc.
   e. Resun by J.M. Huber Corp.
   f. Xomox Corp.

7. Earthquake-Actuated Automatic Gas Shutoff Valves:
   a. Koso by Pacific Seismic Products, Inc.
   b. Pacific Seismic Products, Inc.
c. Quake Defense, Inc.
d. Quake Master, Inc.

8. Solenoid Valves:
   a. Atkomatic Valve Co., Inc.
   b. Automatic Switch Co.
   c. Magnatrol Valve Corp.
   d. Skinner Valve Div., Honeywell, Inc.

2.2 PIPES AND TUBES

A. Steel Pipe: ASTM A 53, Type E, Electric-Resistance Welded or Type S, Seamless, Grade B, Schedule 40, black.

2.3 PIPE AND TUBE FITTINGS


B. Unions: ASME B16.39, Class 150, black malleable iron; female pattern; brass-to-iron seat; ground joint.

C. Steel Fittings: ASME B16.9, wrought steel, butt-welding type; and ASME B16.11, forged steel.

D. Steel Flanges and Flanged Fittings: ASME B16.5.


F. Transition Fittings: Type, material, and end connections to match piping being joined.

2.4 JOINING MATERIALS

A. Common Joining Materials: Refer to Division 23 Section “Basic Mechanical Materials and Methods” for joining materials not included in this Section.

B. Joint Compound and Tape: Suitable for natural gas.

C. Gasket Material: Thickness, material, and type suitable for natural gas.

2.5 VALVES

A. Manual Valves: Conform to standards listed, or where appropriate, valves according to ANSI Z21.15 and ANSI Z21.15a.

B. Gas Valves, 2 Inches and Smaller: ASME B16.33, 150 psi WOG, bronze body, bronze plug, straightaway pattern, square head, tapered-plug type, with threaded ends.

   1. Option: Include locking (tamperproof) feature.

C. Gas Valves, 2-1/2 Inches and Larger: MSS SP-78, Class 125 or 175 WOG, nonlubricated plug type with PTFE lining or sleeve, semisteel body, wrench operated, with flanged ends.

   1. Option: Include locking (tamperproof) device feature.
D. Valve Boxes: Cast-iron, 2-section box. Top section includes cover with lettering “GAS.” Bottom section includes base of size to fit over valve and barrel approximately 5 inches in diameter. Valve box includes adjustable cast-iron extension of length required for depth of bury of valve.

1. Furnish 1 steel operating wrench with each valve box. Include tee-handle with 1 pointed end, stem of length required to operate valve, and socket fitting valve operating nut.

E. Automatic Shut-off Valves: ANSI Z21.21 or ANSI Z21.21a, for operation by appliance automatic shutoff device. Two inches and smaller with threaded ends and 2-1/2 inches and larger with flanged ends.

1. Operation: Mechanical.

F. Earthquake-Actuated Automatic Shut-off Valves: ANSI Z21.70, mechanical operation, with threaded ends for 2 inches and smaller and flanged ends for 2-1/2 inches and larger.

G. Solenoid Valves: Bronze, aluminum, or cast-iron body; 120 volts a.c., 60 Hz, Class B continuous-duty molded coil; UL labeled and FM approved. Include ISC 6, NEMA 4 coil enclosure and electrically opened and electrically closed dual coils. Valve position is normally closed. Include threaded ends for 2 inches and smaller and flanged ends for 2-1/2 inches and larger.

2.6 PIPING SPECIALTIES

A. Gas Meters: Diaphragm-type, positive displacement, with aluminum cases, temperature compensated, with internal corrosion-resistant components. Include threaded ends for 2 inches and smaller; flanged ends for 2-1/2 inches and larger. Meter pressure ratings and flow volume in standard cubic feet per hour of natural gas at specific gravity are as indicated.

2. Capacity, Greater than 500 Cubic Feet per Hour: ANSI B109.2.

B. Gas Meter Bars: Malleable-iron or cast-iron frame for supporting gas meter. Include meter offset swivel pipes, meter nuts with O-ring seal, factory- or field-installed dielectric unions, and threaded ends.

1. Exception: Omit meter offset swivel pipes when meter bar dimensions match gas meter connections.

C. Gas Pressure Regulators: ANSI Z21.18 or ANSI Z21.18a, single stage, steel jacketed, corrosion-resistant pressure regulators. Include atmospheric vent, elevation compensator, with threaded ends for 2 inches and smaller and flanged ends for 2-1/2 inches and larger. Regulator pressure ratings, inlet and outlet pressures, and flow volume in standard cubic feet per hour of natural gas at specific gravity are as indicated.

1. Service Gas Pressure Regulators: Inlet pressure rating not less than natural gas distribution system service pressure.
2. Line Gas Pressure Regulators: Inlet pressure rating not less than system pressure.
3. Appliance Gas Pressure Regulators: Inlet pressure rating not less than system pressure, with capacity and pressure setting matching appliance.
4. Gas Pressure Regulator Vents: Factory- or field-installed corrosion-resistant screen in opening when not connected to vent piping.

E. Strainers: Y pattern, full size of connecting piping. Include Type 304 stainless-steel screens with 3/64-inch perforations except where other screens are indicated.

1. Pressure Rating: 125 psig minimum steam or 175 psig WOG working pressure except where otherwise indicated.

2. Sizes 2 Inches and Smaller: Bronze body, with female threaded ends.

3. Sizes 2-1/2 Inches and Larger: Cast-iron body, with flanged ends.

4. Screwed screen retainer with centered blowdown and pipe plug.

2.7 CONCRETE BASES

A. Specified in other Sections.

PART 3 - EXECUTION

3.1 PREPARATION

A. Precautions: Close equipment shutoff valves before turning off gas to the premises or section of piping. Perform leakage test as specified in “Field Quality Control” Article to determine that all equipment is turned off in the piping section to be affected.

B. Comply with NFPA 54 “Prevention of Accidental Ignition.”

3.2 EXCAVATION

A. Excavation, trenching, and backfilling is specified in Division 2.

3.3 SERVICE ENTRANCE PIPING

A. Extend natural gas piping and connect to gas distribution system (gas service) piping in location and size indicated for gas service entrance to building.

1. Gas distribution system piping, service gas pressure regulator, and gas meter will be provided by gas utility.

2. Gas distribution system piping, service gas pressure regulator, and gas meter are specified in Division 2.

3. Include gas distribution system piping to point indicated.

4. Include gas distribution system piping to point indicated, gas service pressure regulator, and gas meter. Install in piping and specialty arrangement indicated.

B. Install shutoff valve, downstream of gas meter, outside building at gas service entrance.

3.4 CONCRETE BASES

A. Install concrete bases, of dimensions indicated, where indicated, for gas meters, gas pressure regulators, and specialties.
3.5 PIPE APPLICATIONS

A. General: Flanges, unions, transition and special fittings, and valves with pressure ratings same or higher than system pressure rating may be used in applications below, except where specified otherwise.

B. Low-Pressure Natural Gas Systems, above Ground within Building: Use the following:
   1. 2 Inches and Smaller: Steel pipe, malleable-iron, threaded fittings, and threaded joints.
   2. 2-1/2 Inches and Larger: Steel pipe, butt-welding fittings, and welded joints.

C. Medium-Pressure Natural Gas Systems, above Ground within Building: Use steel pipe, butt-welding fittings, and welded joints.

D. High-Pressure Natural Gas Systems, above Ground within Building: Use steel pipe, butt-welding fittings, and welded joints.

3.6 VALVE APPLICATIONS

A. Use low-pressure gas stops, tapered plug or ball type, for shutoff to appliances with 2-inch or smaller low-pressure gas supply.

B. Use gas valves for shutoff to appliances.

C. Use gas valves of sizes indicated for gas service piping, meters, mains, and where indicated.

3.7 JOINT CONSTRUCTION

A. Refer to Division 23 Section “Basic Mechanical Materials and Methods” for basic piping joint construction.

B. Use materials suitable for natural gas service.

3.8 PIPING INSTALLATIONS

A. Refer to Division 23 Section “Basic Mechanical Materials and Methods” for basic piping installation requirements.

B. Concealed Locations:
   1. Above-Ceiling Locations: Gas piping may be installed above-ceiling spaces, whether or not such spaces are used as a plenum. Do not locate valves in such spaces. All joints above ceilings shall be welded.
   2. In Partitions and Walls: Do not install concealed piping in solid partitions or walls. Protect tubing against physical damage when it is installed inside partitions or hollow walls. This does not apply to tubing passing through partitions or walls.
   3. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts. This does not apply to accessible above-ceiling space specified above.

C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of gas meters, and at all equipment connections. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate would be subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, except where indicated to be exposed to view.

E. Install gas piping at a uniform grade of 1/4 inch in 15 feet, upward toward risers. Install piping upward from service risers to meters, service regulator when meter is not provided, and equipment.

F. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

G. Connect branch piping from top or side of horizontal piping.

H. Install unions in pipes 2 inches and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

I. Install dielectric fittings (unions and flanges) with 1 ferrous and 1 brass or bronze-end connections, separated by insulated material, where piping of dissimilar metals are joined.

J. Install dielectric fittings (unions and flanges) with 2 ferrous end connections, separated by insulated material, at outlet from gas meter and, where indicated, for ferrous piping.

K. Install flanges on valves, specialties, and equipment having 2-1/2-inch and larger connections.

L. Anchor piping to ensure proper direction of piping expansion and contraction. Install expansion joints, expansion loops, and pipe guides as indicated.

M. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing elbow fittings with corrosion-resistant insect screens in large end.

N. Install containment conduits for buried gas piping within building in gas-tight conduits extending 4 inches minimum outside building and vented to atmosphere. Terminate vents with turned-down, reducing elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal tar epoxy-polyamide paint according to SSPC Paint 16.

O. Install underground plastic gas distribution piping according to ASTM D 2774.

3.9 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 23 Section “Supports and Anchors” for hanger and support devices.

B. Install hangers for horizontal piping with following maximum spacing and minimum rod sizes:

<table>
<thead>
<tr>
<th>Nominal Pipe Size (Inches)</th>
<th>Steel Pipe Max. Span (Feet)</th>
<th>Min. Rod Diameter (Inches)</th>
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<td>6</td>
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<td>1-1/2 to 2</td>
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<tr>
<td>Nominal Pipe Size (Inches)</td>
<td>Steel Pipe Max. Span (Feet)</td>
<td>Min. Rod Diameter (Inches)</td>
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<td>4 and larger</td>
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<td>5/8</td>
</tr>
</tbody>
</table>

1. Support vertical steel pipe and copper tube at each floor.

3.10 VALVE INSTALLATION
A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.
B. Install a gas valve upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.
C. Install pressure-relief or pressure-limiting devices so they can be readily operated to determine if valve is free; test to determine pressure at which they will operate; and examine for leakage when in closed position.

3.11 CONNECTIONS
A. Install gas piping next to gas-utilizing equipment and appliances to allow servicing and maintenance.
B. Connect gas piping to gas-utilizing equipment and appliances with shutoff valves and unions. Make connections downstream of valves and unions, with flexible connectors where indicated.
C. Electrical Connections: Wiring is specified in other Divisions.

3.12 TERMINAL EQUIPMENT CONNECTIONS
A. Install a gas valve upstream and within 6 feet of each gas-utilizing appliance. Install a union or flanged connection downstream from the valve to permit removal of controls.
B. Sediment Traps: Install tee fittings forming drips, as close as practical to gas appliance inlets. Cap or plug bottom outlet.

3.13 ELECTRICAL BONDING AND GROUNDING
A. Install above-ground portions of natural gas piping systems that are upstream from equipment shutoff valves, electrically continuous and bonded to a grounding electrode according to NFPA 70.
B. Do not use gas piping as a grounding electrode.

3.14 FIELD QUALITY CONTROL
A. Inspect, test, and purge natural gas systems according to NFPA 54, Part 4 “Gas Piping Inspection, Testing, and Purging” and local gas utility requirements.
B. Repair leaks and defects with new materials, and retest system until satisfactory results are obtained.
C. Report test results promptly and in writing to the Architect and the authority having jurisdiction.
D. Verify capacities and pressure ratings of gas meters, regulators, valves, and specialties.
E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.15 ADJUSTING

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

END OF SECTION
SECTION 230000 GENERAL REQUIREMENTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative and procedural requirements for all HVAC work. The administrative and procedural requirements included in this Section are to expand the requirements specified elsewhere.

1.2 SCOPE OF WORK

A. Provide all labor, material, equipment, and services necessary for and incidental to completion of all work as indicated on the Drawings and/or as specified herein. This includes all incidentals, equipment, appliances, services, hoisting, scaffolding, supports, sleeves, inserts, anchor bolts, tools, supervision, labor, consumable items, fees, licenses, etc., necessary to provide complete and workable systems.

1.3 DRAWING USE AND INTERPRETATION

A. Unless indicated by specific dimensions, drawings are meant to be diagrammatic. Exact equipment locations and routing of utilities shall be governed by field conditions and/or Owner’s Representative’s instructions.

B. All dimensions which relate to the building shall be taken as construction progresses. All errors incurred as result of the failure to check or verify dimensions, measurements, etc., shall be corrected.

C. The drawings show the general arrangement of utilities, equipment, and accessories. Drawings do not indicate all offsets, fittings, accessories, and changes in elevation, which may be necessary. Make all changes in equipment, locations, etc., to accommodate the work and to avoid obstacles at no increase in contract price. Provide offsets, fittings, and accessories as may be required to meet such conditions.

1.4 SPECIFICATION FORMAT AND CONTENT EXPLANATION

A. Specification Content: This Specification uses certain conventions regarding the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions are explained as follows:

1. Abbreviated Language: Language used in Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be interpolated as the sense requires. Singular words will be interpreted as plural and plural words interpreted as singular where applicable as the context of the Contract Documents indicates.

2. Streamlined Language: The Specifications generally use the imperative mood and streamlined language. Requirements expressed in the imperative mood are to be performed by the Contractor. At certain locations in the Text, subjective language is used for clarity to describe responsibilities that must be fulfilled indirectly by the Contractor or by others when so noted.

a. The words “shall be” are implied where a colon (:) is used within a sentence or phrase.
1.5 DEFINITIONS

A. General: Basic Contract definitions are included in the conditions of the Contract.

B. Indicated: The term “indicated” refers to graphic representations, notes or schedules on the Drawings, or other Paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents. Where terms such as “shown,” “noted,” “scheduled,” and “specified” are used, it is to help the reader locate the reference; no limitation on location is intended.

C. Directed: Terms such as “directed,” “requested,” “authorized,” “selected,” “approved,” “required,” and “permitted” mean “directed by the Engineer,” “requested by the Engineer,” and similar phrases.

D. Approved: The term “approved,” where used in conjunction with the Engineer’s action on the Contractor’s submittals, applications, and requests, is limited to the Engineer’s duties and responsibilities as stated in the Conditions of the Contract.

E. Regulations: The term “Regulations” includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.

F. Furnish: The term “furnish” is used to mean “supply and deliver to the Project site, ready for unloading, unpacking, assembly, installation, and similar operations.”

G. Install: The term “install” is used to describe operations at project site including the actual “unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.”

H. Provide: The term “provide” means “to furnish and install, complete and ready for the intended use.”

I. Installer: An “installer” is the Contractor or an entity engaged by the Contractor, either as an employee, subcontractor, or contractor of lower tier for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

1. The term “experienced,” when used with the term “installer,” means having a minimum of five previous projects similar in size and scope to this Project, being familiar with the special requirements indicated, and having complied with requirements of the authority having jurisdiction.

2. Trades: Use of titles such as “carpentry” is not intended to imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as “carpenter.” It also does not imply that requirements specified apply exclusively to trades persons of the corresponding generic name.

3. Assignment of Specialists: Certain Sections of the Specifications require that specific construction activities shall be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and assignments are requirements over which the Contractor has no choice or option. Nevertheless, the ultimate responsibility of fulfilling Contract requirement remains with the Contractor.

a This requirement shall not be interpreted to conflict with enforcement of building codes and similar regulations governing the Work. It is also not intended to interfere with local trade union jurisdictional settlements and similar conventions.
J. The term “concealed”: embedded in masonry or other construction, installed behind wall furring, within partitions or hung ceilings (permanent or removable), in trenches, or in crawl spaces.

K. The term “exposed”: not installed underground or concealed. Equipment in rooms with exposed construction (i.e. mechanical rooms, electrical rooms, janitor’s closets, etc.) are classified as exposed.

L. The term “piping”: piping fittings, flanges, valves, controls, hangers, traps, drains, insulation and items necessary or required in connection with or relating thereto.

M. The “Project Site” is the space available to the contractor for performance of construction activities, either exclusively or in conjunction with other performing other work as part of the Project.

N. Testing Laboratories: A “testing laboratory” is an independent entity engaged to perform specific inspections or tests, either at the Project Site or elsewhere, and to report on and, if required, to interpret results of those inspections or tests.

1.6 COMPLETE SYSTEMS

A. General: Provide all materials as required for complete systems, including all parts obviously or reasonably incidental to a complete installation, whether specifically indicated or not. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation prior to Owner’s acceptance.

B. Systems: The systems specified and/or shown on the Drawings are for complete and workable systems. Any deviation from these systems due to a particular manufacturer’s requirements shall be made at no additional cost to the Owner.

1.7 CODES AND REGULATIONS

A. General: Comply with all governing federal, state, and local laws, ordinances, codes, rules, and regulations. Where the Contract Documents exceed these requirements, the Contract Documents shall govern. In no case shall work be installed contrary to or below minimum legal standards.

B. Utilities: Comply with all applicable rules, restrictions, and requirements of the utility companies serving the project site/facilities. Contractor shall be required to contact state regulated “call before you dig” service prior to any excavation work.

C. Non-Compliance: Should any work be performed which is found not to comply with any of the above codes and regulations, provide all work and pay all costs necessary to correct the deficiencies.

1.8 REFERENCE STANDARDS

A. All published standards of the following associations/organizations, as mandated by specific state standards, shall be followed and applied as a minimum.

   AABC  Associated Air Balance Council
   ACI   American Concrete Institute
   AGA   American Gas Assoc.
   AIA   The American Institute of Architects
   AISC  American Institute of Steel Construction
   AMCA  Air Movement and Control Assoc.
   ANSI  American National Standards Institute
ARI Air-Conditioning and Refrigeration Institute
ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME American Society of Mechanical Engineers
ASPE American Society of Plumbing Engineers
ASSE American Society of Sanitary Engineering
ASTM American Society for Testing and Materials
AWS American Welding Society
DIPRA Ductile Iron Pipe Research Assoc.
ETL ETL SEMKO a Division of Intertek Group
FMG Factory Mutual Global
HEI Heat Exchange Institute
HI Hydronics Institute
ISA Instrument Society of America
MCAA Mechanical Contractors Association of America
MSS Manufacturers Standardization Society
NACE National Association of Corrosion Engineers International
NADCA National Air Duct Cleaners Association
NEC National Electrical Code (from NFPA)
NECA National Electrical Contractors Assoc.
NEMA National Electrical Manufacturers Assoc.
NFPA National Fire Protection Assoc.
SMACNA Sheet Metal and Air Conditioning Contractors
STI Steel Tank Institute
UL Underwriters Laboratories Inc.

B. Federal Government Agencies: Names and titles of federal government standard- or Specification-producing agencies are often abbreviated. The following acronyms or abbreviations referenced in the Contract Documents indicate names of standard- or Specification-producing agencies of the federal government. Names are subject to change and are believed, but are not assured, to be accurate and up-to-date as of the date of the Contract Documents.

EPA Environmental Protection Agency
NIST National Institute of Standards and Technology (U.S. Department of Commerce)
OSHA Occupational Safety and Health Administration (U.S. Department of Labor)

C. Applicability of Standards: Except where the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents. Such standards are made a part of the Contract Documents by reference.

D. Copies of Standards: Each entity engaged in construction on the project is required to be familiar with industry standards applicable to that entity’s construction activity. Copies of applicable standards are not bound with the Contract Documents. Where copies of standards are needed for performance of a required construction activity, the contractor shall obtain copies directly from the publication source.

1.9 QUALITY ASSURANCE

A. Manufacturers’ Qualifications: Not less than five years experience in the actual production of the specified products.

B. Installers’ Qualifications:

1. Firm with not less than five years experience in the installation of mechanical systems and
equipment similar in scope and complexity to those required for this Project, and having successfully completed at least ten comparable scale projects.

2. Painting, patching, carpentry and the like related to or required for Division 23 work shall be performed by craftsmen skilled in the appropriate trade.

3. All welding shall be performed by ASME certified welders.

1.10 INSPECTIONS

A. General: During and upon completion of the work, arrange and pay all associated costs for inspections of all work installed under this Contract, in accordance with the Conditions of the Contract.

B. Inspections Required: As per the laws and regulations of the local and/or state agencies having jurisdiction at the project site.

C. Inspection Agency: Approved by the local and/or state agencies having jurisdiction at the project site.

PART 2 - PRODUCTS

2.1 GENERAL

A. Where Specified: Materials and equipment shall be as specified in subsequent sections of the Project Manual and/or as indicated on the Drawings.

B. General: All materials and equipment to be new, clean, undamaged, and free of defects and corrosion.

C. Acceptable Products: The product will be acceptable only when that product complies with all requirements of the Contract Documents as determined by the Engineer.

D. Common Items: Where more than one of any specific item is required, all shall be of the same type and manufacturer.

E. Listing: All materials and equipment shall be Underwriters’ Laboratories (UL) or ETL SEMKO (ETL) listed and labeled, where UL or ETL standards and listings exist for the specified materials or equipment.

F. Special Tools: Provide all special tools needed for proper operation, adjustment and maintenance of equipment.

PART 3 - EXECUTION

3.1 GENERAL

A. The installation of all mechanical work shall be in accordance with the letter and intent of the Contract Documents, as determined by the Engineer.

B. Installation Requirements: All materials and equipment shall be installed as recommended by the respective manufacturers, by mechanics experienced and skilled in their particular trade, in a neat and workmanlike manner, in accordance with the standards of the trade, and so as not to void any warranty, UL or ETL listing.
3.2 DELIVERY STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original, unopened packaging, properly identified with manufacturer’s identification, and compliance labels.

B. Storage and Protection: Comply with all manufacturer’s written recommendations. Protect all equipment, materials and work from the weather elements, paint, mortar, construction debris and damage throughout duration of project.

C. Damaged Products: Do not install damaged products. Arrange for prompt replacement.

3.3 EXAMINATION

A. Conditions Verification: Examine the areas and conditions under which the work is to be performed. Identify and Report any conditions detrimental to the proper and timely completion of the work to the Owner’s Representative.

3.4 DIMENSIONS

A. Building Dimensions: Exact locations of building elements shall be based on contractor’s field measurements.

B. Limiting Dimensions: Where equipment dimension and clearances are indicated on the Drawings, do not provide equipment larger than equipment dimensions or clearances specified.

C. Verify all dimensions by field measurements.

3.5 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.6 CUTTING AND PATCHING

A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of non-coordinated and/or improperly installed work.
2. Remove and replace defective Work.
3. Remove and replace Work not conforming to requirements of the Contract Documents.
4. Remove samples of installed Work as specified for testing.
5. Install equipment and materials in existing structures.
6. Uncover and restore Work to provide for Engineer observation of concealed Work.

C. Cut, remove and legally dispose of equipment, components, and materials as indicated. Removal shall include all ancillary items associated with items removed. Remove all items made obsolete by the new work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated to be removed.
E. Provide and maintain temporary dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

F. Patch surfaces and building components using new materials matching existing adjacent materials.

3.7 ADMINISTRATION AND SUPERVISION

A. The Contractor shall supervise the work and shall have at all times some competent person, approved by the Owner, following the work to receive instructions and to act with authority.

3.8 TESTING AND ADJUSTING

A. General: Provide testing equipment, materials, instruments, and personnel to perform all test procedures and adjustments required by the Contract Documents and/or deemed necessary by the Engineer to establish proper performance and installation of systems and equipment. All test instruments to be accurately calibrated and in good working order.

B. Scheduling: Schedule tests at least three days in advance, and so as to allow Engineer and Owner representative(s) to witness the test, unless directed otherwise. Do not schedule tests until the system installation is complete and fully operational, unless indicated or directed otherwise.

C. Correction/Replacement: After testing, correct any deficiencies, and replace materials and equipment shown to be defective or unable to perform at design or rated capacity. Retest without additional cost to the Owner or Contract. Submit finalization report indicating corrective measures taken, and satisfactory results of retest.

3.9 SYSTEMS DEMONSTRATION

A. Instruct the Owner’s representative(s) in the start-up, operation and maintenance of all systems and equipment in accordance with the Contract Documents.

3.10 CLEANING

A. General: Remove from the project site, all waste, rubbish and construction debris weekly unless indicated otherwise. The premises shall be left clean and free of any debris and unused construction materials, prior to final acceptance.

B. Equipment: Remove all dust, dirt, debris, mortar, rust, and other foreign materials from the interior and exterior of all equipment and enclosures, and wipe down.

C. Utilities: Thoroughly clean all utilities, just prior to final inspection.

3.11 TOUCH-UP PAINTING

A. Touch-Up Painting: Restore and refinish to original condition, all surfaces of equipment scratched, marred and/or dented during shipping, handling, or installation. Remove all rust, and prime and paint as recommended by the manufacturer.

END OF SECTION
SECTION 230004 COORDINATION WITH OTHER TRADES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This section describes the coordination and procedural requirements for Contractors.

B. Definitions:

1. Owners Representative - Architect, Engineer, Construction Manager, General Contractor, Clerk of the works or any stipulated Agent or Representative of the Owner.

2. GC - General Contractor.

3. MC - Mechanical Contractor/Subcontractor.

4. EC - Electrical Contractor/Subcontractor.

5. SM - Sheet Metal Subcontractor.

1.2 COMPLIANCE

A. Cost incurred including those of other contractors and/or Owner, due to non-compliance with this Section shall be the responsibility of the non-compliant contractor.

1.3 SUBMITTALS

A. Complete coordinated shop drawing shall be submitted in PDF and ACAD format to the Engineer for their record by the MC. Submitted coordinated shop drawing shall include all signatures required by sign off procedure.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 COORDINATION

A. General: Sequence, coordinate and integrate the installation of all materials and equipment for efficient flow of work, in conjunction with the other trades. Review and become familiar with all of the Drawings and work of all the other trades. Report and resolve any discovered discrepancies and/or interferences prior to commencing work.

B. Cooperation: Cooperate with the other Contractors and individual disciplines for placement, anchorage and accomplishment of the work.

C. Chases, Slots, and Openings: Arrange for chases, slots, and openings during the progress of construction, as required to allow for installation of the work.

D. Supports and Sleeves: Coordinate the location installation of required supporting devices and sleeves to be set in concrete and other structural components, as they are constructed.
E.  Right-Of-Way:

1. Adjust location of utilities, equipment, etc., to accommodate the work to prevent interferences, both anticipated and encountered.

2. Determine the exact route and location prior to fabrication.

3. Pitched piping has the right-of-way over utilities which do not pitch.

4. Furnish and install auxiliary materials & equipment including but not limited to traps, air vents, drains, etc., as required to accommodate offsets, transitions and changes in direction.

F.  Headroom:  Install systems, materials, and equipment to maximize headroom unless noted otherwise.

G. Utility Connections:  Coordinate connection with underground and overhead utility services.  Comply with requirements of governing regulations, utility providers, and controlling agencies.  Provide required connection for each service.

3.2  COORDINATED SHOP DRAWINGS

A.  The coordination shop drawing process shall occur in the following manner:

1. The MC shall create 3/8” scale AutoCAD (2002 or newer) base plans which shall incorporate and coordinate with structural steel and ceiling system framing supports and show framing members on the shop drawings.  This shall include existing building components not shown on Contract Documents.

2. The MC shall require the Sheet Metal Subcontractor to submit AutoCAD shop drawings, as expeditiously as possible, to the Engineer (through normal channels) for review and approval.  The shop drawings shall incorporate all ductwork (including top and bottom of duct elevations at a maximum interval of 25 linear feet and at each elevation change), structural steel (building and misc. support steel), equipment and accessories as shown and/or specified in the contract documents.

3. All roof penetrations, wall and floor openings shall be coordinated with the structural steel Subcontractor, Supplier and/or Erector, through the Owner’s Representative.  All conflicts with structural steel members shall be resolved through the Owner’s Representative.

4. After review and final approval of the sheet metal shop drawing by the Engineer, the sheet metal Subcontractor shall incorporate all required corrections, additions and modifications on the AutoCAD ductwork shop drawings.

5. The approved AutoCAD ductwork shop drawings shall be utilized for coordination with all other Contractors or Subcontractors whose involvement is mandated.  The SM shall submit the AutoCAD ductwork shop drawings (hard copy and electronic files) to the MC to initiate the “coordination” process.  The MC shall review the drawings for accuracy and completeness prior to distribution.

6. When it is ascertained that no conflicts exist between the MC and SM, the MC shall forward the final ductwork/mechanical coordinated drawings (hard copy and electronic files) to the EC with transmittal, and provide the Owner’s Representative with a copy of the transmittal.

7. The EC shall (upon receipt of drawings from the MC) superimpose all electrical equipment including but not limited to light fixtures, conduit and hangers on the AutoCAD drawings.
8. The EC shall include elevations of light fixtures, electrical conduit and conduit sizes.

9. Any conflicts with the ductwork/mechanical/electrical work shall be clouded by the EC on the AutoCAD shop drawing file.

10. EC shall request coordination meeting to resolve any conflicts as clouded on the coordinated shop drawings. EC shall provide clouded coordinated shop drawing at the coordination meeting. All conflicts that arise between the EC, MC and SM shall be resolved through and by the Owner’s Representative.

11. The EC and/or the SM, MC shall correct and complete the AutoCAD drawings depicting all resolutions.

12. When it is ascertained that no conflicts exist between the EC, MC and SM, the EC shall forward the final ductwork/plumbing/mechanical/electrical coordinated drawings (hard copy and electronic file) to the MC with transmittal, and provide the Owner’s Representative with a copy of the transmittal.

13. Sign Off:
   a. The MC shall provide the final coordinated shop drawing to the Engineer and the Owner's Representative. The final coordinated shop drawing shall contain signatures from SM, MC, EC and SC on each sheet.
   b. Upon completion of the coordination process by all Contractors and Subcontractors as described above, they shall sign off on all drawings in ink indicating company, name, date of sign-off and signature of company representative.
   c. Each contractor signature shall certify that each Contractor has shown their respective work on the drawings and have resolved all points of conflict and interference with other Contractors and Subcontractors.

3.3 COORDINATION MEETINGS

A. During the coordination process, separate meetings apart from project meetings concerning the progress and schedules may be called by the Owner’s Representative when required or at the request of one or more of the coordinating Contractors.

1. The Owner’s Representative shall contact the Contractors and make all required arrangements, e.g. time, place, etc.

2. All Contractors shall place emphasis and importance on equipment purchases, so as to not delay approvals, shop drawings and the coordinated drawings.

3.4 SCHEDULE OF COORDINATED SHOP DRAWINGS

A. The MC and SM shall complete the ductwork shop drawings within two (2) weeks after award of contract (or authorization to proceed).

B. Turn-around time for each Contractor shall be two (2) weeks maximum.

3.5 "AS BUILT" DRAWINGS

A. At the completion of the project, “As Built” corrections shall be made to each AutoCAD drawing by each of the aforementioned Contractors and returned to the Owner’s Representative for the Owner’s
permanent files and records. These “As Built” do not remove the obligation of “As Built” and record drawings as outlined under other sections of the specifications unless the Owner’s Representative elects to do so.

END OF SECTION
SECTION 230500- BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following basic materials and methods to complement other Division 23 Sections.

1. Piping installation instructions common to most piping systems.
2. Dielectric fittings.
3. Flexible connectors.
4. Mechanical sleeve seals.
5. Sleeves.
7. Fire Stopping.
8. Identifying devices and labels.
10. Interior concrete housekeeping pads.
11. Installation requirements common to equipment specification sections.
12. Touch-up painting.
13. Removals.

B. Pipe, pipe fittings and joining materials and methods are specified in Division 23 piping system sections.

1.2 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, crawl spaces, and tunnels.

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

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

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

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

F. The following are industry abbreviations for plastic materials:
   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PVC: Polyvinyl chloride plastic.

G. Existing: Condition present prior to award of this contract.
1.3 SUBMITTALS

A. Product Data: For all materials specified within this section

B. Fire Rated Penetration Listing Details: Submit Underwriters Laboratory penetration listing details specific to the penetrations required by the project along with fire stopping material data.

C. Quality Control Submittals: Fire stopping certificates specified in Quality Assurance below.

1.4 QUALITY ASSURANCE

A. Fire Stopping: Fire stopping installer shall be certified by the fire stopping manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Protect piping, flanges, fittings, and piping specialties to prevent pipe end damage. Maintain end caps through shipping, storage, and handling.

B. Store plastic pipes in locations not subject to direct sunlight.

C. Protect all stored materials from moisture and dirt. Elevate above grade and support to prevent sagging and bending. Do not exceed structural capacity of floor, if stored inside.

1.6 SEQUENCING AND SCHEDULING

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

B. Install identifying devices before concealment.

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. Dielectric Components:
   a. Watts Water Technologies, Inc.
   b. Grinnell Corp.; Grinnell Supply Sales Co.
   c. Victaulic Co. of America.

2. Metal, Flexible Connectors:
   a. Engineered Flexible Products.
   b. Flexicraft Industries.
   c. Grinnell Corp.; Grinnell Supply Sales Co.
   d. Mercer Rubber Co.
   e. Metraflex Co.

3. Mechanical Sleeve Seals:
   a. Calpico, Inc.
   b. Metraflex Co.
   c. Proco Products, Inc.
   d. Thunderline/Link-Seal.
4. Fire-Stopping Sealant:
   a. Dow Corning Corp.
   b. 3M Corp.
   c. Hilti Corp.

5. Pipe Escutcheons:
   c. Grinnell.

6. Identifying Devices:
   b. Seton Identification Products.
   c. W.H. Brady Company.

2.2 DIELECTRIC FITTINGS

A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.

B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.

C. Insulating Material: Suitable for system fluid, pressure, and temperature.

D. Dielectric-Flange Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Dielectric flange kit materials shall be compatible with system fluid, temperature and pressure.

E. Dielectric Couplings: ARE NOT ALLOWED

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; and 300-psig (2070-kPa) minimum working pressure at 225°F (107°C). Coordinate end selection with piping system specifications.

2.3 FLEXIBLE CONNECTORS

A. General: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections. Include 125-psig (860-kPa) minimum working-pressure rating at 220°F, unless higher working pressure or temperature is indicated. Coordinate end selection with piping system specifications.

B. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors (non-potable applications only): Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

2.4 MECHANICAL SLEEVE SEALS

A. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with stainless steel bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical isolation.
2.5 SLEEVES

A. General: The following materials are for wall, floor, slab and roof penetrations.

B. Pipe:

1. Steel Sheet Metal: 0.0359-inch (0.9-mm) minimum thickness, galvanized, round tube closed with welded longitudinal joint.


3. Cast Iron: Cast or fabricated pipe equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

C. Ductwork

1. All sleeves shall be per SMACNA.

2.6 ESCUTCHEONS

A. General: Manufactured wall, ceiling, and floor plates; deep-pattern type if required to conceal protruding fittings and sleeves.

1. ID: Closely fit around pipe, tube, and insulation of insulated piping.
2. OD: Completely cover opening.
3. Stamped Steel: One piece, with set screw and chrome-plated finish.

2.7 FIRE STOPPING

A. UL listed material specific to the UL penetration listing detail.

2.8 IDENTIFYING DEVICES AND LABELS

A. Equipment Nameplates: Metal nameplate with operational data engraved or die-stamped; permanently fastened to equipment.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

B. Stick-on Pipe Markers: Manufacturer’s standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, complying with ASME A13.1.

C. Stick-on Duct Markers: Manufacturer’s standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, complying with ASME A13.1.

D. Stick-on Flow Marker: Manufacturer’s standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl, two inch (2”) wide band, color coded complying with ASME A13.1.
E. Rigid Pipe Markers: Manufacturer’s standard preprinted, color coded, rigid plastic with flow arrows and fluid medium designed to be applied to piping systems without the need of adhesives. For markers up to 6 inch, markers shall wrap completely around the pipe, and their own tension shall secure them in place. For markers over 6 inch, markers shall be provided with nylon ties to secure marker to piping system. Markers comply with ANSI/ASME A13.1.

F. Valve Tags: Stamped or engraved 0.032-inch (0.8-mm-) thick, polished brass, 1-1/2-inches (40-mm) diameter, with 1/4-inch (6-mm) piping system abbreviation letters and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole and brass, wire-link or beaded chain; or brass S-hook fastener.

G. Framed Valve Schedule: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include appropriate mounting hardware. Valve schedule shall be 8-1/2” x 11” with a minimum font height of 12 pt. Frame shall be extruded aluminum with ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass. Schedule shall include valve number, piping system, system abbreviation as shown on valve tag, location of valve (room or space), normal operating position (open, closed or modulating). Indicate valves utilized for emergency shut off or other special purposes.

H. Access Panel Markers: 1/16-inch (2-mm-) thick, engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed valve. Provide 1/8-inch (3-mm) center hole for attachment.

I. Plastic Equipment Markers: ASME A13.1, color-coded, laminated plastic. Include lettering identifying name, equipment service, design capacity, pressure drop, entering and leaving conditions and RPM indicated on the contract documents. Size shall be 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; and 4-1/2 by 6 inches (115 by 150 mm) for equipment. Identifying names and/or abbreviations shall match those indicated on the contract documents.

2.9 GROUT

A. Non-shrink, Non-metallic Grout: ASTM C 1107, Grade B, post-hardening, volume-adjusting, dry, non-staining, non-corrosive, non-gaseous, hydraulic-cement grout recommended for interior and exterior applications. Design mix shall be 5000-psig (34.5-MPa), 28-day compressive strength.

2.10 INTERIOR CONCRETE HOUSEKEEPING PADS

A. Concrete: 3000-psig (20.7-MPa), 28-day compressive-strength concrete.

B. Form work: 14 gauge galvanized steel frame.

C. Dowels: #4 rebar.

D. Reinforcement: 6 X 6 –W2.9 X W 2.9 wire metal mesh at center.

E. Modified Existing Pads: refer to drawing details.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. General: Install piping as described below, unless piping sections specify otherwise.

B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.
C. Install components with pressure and temperature ratings equal to or greater than system operating pressure and temperature.

D. Install piping free of sags and bends. Install fittings for changes in direction and branch connections. Install fittings, couplings, and accessories according to manufacturer’s written instructions.

E. Install piping at parallel and perpendicular to building walls. Diagonal runs are prohibited, unless otherwise indicated. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

F. In areas of exposed piping, install piping to maximize headroom. In areas with ceilings, install piping to maximize clearance between ceiling and pipe. Allow sufficient space for ceiling panel removal.

G. Install piping to allow application of insulation plus 1-inch (25-mm) clearance around insulation.

H. Install pipe escutcheons for pipe penetrations of walls, partitions, floors and ceilings.

I. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, ¾” ball valve, threaded nipple and chained cap.

J. Install line size manual shutoff valve at each connection to each piece of equipment.

K. Install piping so that accessories are accessible for operation, maintenance, repair and replacement.

L. Install piping with sufficient clearance to allow for expansion and contraction.

M. Sleeves are not required for core drilled holes through interior solid concrete walls and floors, above grade exterior solid concrete walls and existing underground solid concrete walls. Floors in mechanical equipment areas or other wet areas shall be provided with a sleeve with waterstop.

N. Install sleeves for pipes passing through walls, partitions, and slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. In floors with water stop extend cast-iron sleeve fittings below floor slab as required to secure clamping ring.

2. Build sleeves into new walls and slabs as walls and slabs are being constructed.

3. Install sleeves in non-fired rated assemblies large enough to provide 1/2-inch (12.7-mm) annular clear space between sleeve and pipe or pipe insulation.

4. Install sleeves in fire rated assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

O. Interior Wall and Floor Pipe Penetrations: Sleeves shall be steel pipe except steel sheet metal shall be used for gypsum wall penetrations.

P. Water Proof Floor and Roof Pipe Penetrations: For pipes penetrating floors and roofs with membrane waterproofing install stack sleeve fitting. Secure flashing between clamping flanges. Seal space outside of sleeve fittings with non-shrink, non-metallic grout. Provide Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant between sleeve and pipe.
Q. Aboveground, Exterior-Wall, Pipe Penetrations:


2. Non-Masonry or Non-Concrete Walls: Provide wall plate matching surrounding construction. Fill gap between wall opening and pipe with mineral wool. Provide Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant between wall plate and wall.

R. Underground, Exterior-Wall, Pipe Penetrations: Provide cast-iron or galvanized steel sleeves with integral waterstop, except for existing walls. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for annular clear space between pipe and sleeve for installing mechanical sleeve seals. Annular clear space shall be per mechanical sleeve seal manufacturer’s written recommendation. Assemble and install mechanical sleeve seals according to manufacturer’s written instructions.

S. Verify final equipment locations for rough-in.

T. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections:

1. Threaded Steel Pipe Joints: Thread pipe with tapered pipe threads in accordance with ANSI B2.1 and ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended at each joint and tighten joint to leave not more than 3 threads exposed. 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.


3. Flanged Steel Pipe Joints: Clean flange faces and install gaskets. Align flange surfaces parallel. Use suitable lubricants on bolt threads. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.

4. Copper Pipe Joints: Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

5. Gasket Materials: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.

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

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

8. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following:

   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
b. CPVC Piping: ASTM D 2846 and ASTM F 493.

c. PVC Pressure Piping: ASTM D 2672.

d. PVC Nonpressure Piping: ASTM D 2855.

U. Piping Connections: Make connections according to the following, unless otherwise indicated:

1. Remake leaking joints using new materials.

2. Install unions, in piping 2-inch NPS (DN50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

3. Install flanges, in piping 2-1/2-inch NPS (DN65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.


3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting and without interference(s) to other installations.

D. Extend grease fittings to accessible locations.

3.3 FIRE STOPPING

A. Fire Stopping: At penetrations through fire rated walls, partitions, barriers, ceilings, roofs or floors, the fire rated integrity shall be maintained. Provide manufacturer’s standard fire-stopping sealant, with accessory materials, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

3.4 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on all piping of each system (insulated and un-insulated), including pipe sizes, fluid medium and direction of flow arrows.

1. Interior, non-metal jacketed piping systems: Provide stick-on markers. Install flow marker 360 degrees at each end of each pipe marker.

2. Interior metal jacketed and exterior piping systems: Provide rigid markers (for markers on piping over 6 inches provide nylon ties). Provide stick-on size marker attached to rigid marker.

3. Markers shall be spaced at a maximum of 25-foot (7.5-m) intervals along each run. In addition to the 25 foot intervals, provide markers at the following locations:

a. Near each valve and control device.
b. Near each branch, excluding short takeoffs for fixtures and terminal units.

c. Near locations where pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.

d. At access doors, manholes, and similar access points that permit view of concealed piping.

e. Near major equipment items and other points of origination and termination.

B. Valve Tags

1. Install on all valves and control devices (factory and field installed), except check valves. List tagged valves in valve schedule.

2. Provide framed valve schedule(s) where directed by owners representative.

C. Install plastic equipment marker on all equipment provided under this contract.

D. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers. Duct markers shall identify service and direction of flow. Locate markers at maximum intervals of 50 feet (15m), near points where ducts enter and exit the space, and on ducts located behind all access doors.

E. Provide additional mechanical identification materials and devices to supplement field or factory supplied nameplates that have become visually blocked by work of this or other Divisions.

F. Clean faces of identification devices and glass frames of valve charts.

3.5 TOUCH-UP PAINTING

A. Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 GROUTING

A. Install nonmetallic, non-shrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix and cure grout according to manufacturer’s written instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placing of grout.

E. Place grout to provide smooth bearing surface for equipment base.

F. Place grout, completely filling equipment bases.

G. Place grout around anchors.

3.7 INTERIOR CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for all floor mounted equipment. Provide 6” tall 3000 psi concrete pad having 6 X 6 – W2.9 X W 2.9 wire metal mesh at center. Extend pad a minimum of 4”
greater than equipment footprint in all directions. Provide a smooth trowel finish on top surface of pad.

B. Provide 14 gauge galvanized steel frame around entire perimeter of pad having a ¾” chamfer at all corners and at all edges. Frame to extend ½” over top of pad and 1” beneath bottom surface of pad. All corners to be welded.

C. Anchor pad to existing or new concrete floor with #4 rebar dowels set at a minimum 12” on center in each direction, having the last 2” of dowel bent at a 90 degree angle.

   1. Existing floors: Drill 1” diameter bores into the existing concrete floor at a minimum depth of 2” to accept dowels. Fasten dowels within bores with epoxy grout.

   2. Newly poured floors: Provide rebar dowels embedded to a depth of 2” below floor surface, having the last 2” of dowel bent at a 90 degree angle.

D. Prior to pouring concrete pad, place manufacture’s recommended galvanized steel anchor bolts into pad using the equipment template provided.

E. Provide 5000 psi level grout bedding beneath equipment prior to setting and final tightening of fasteners.

3.8 REMOVALS

A. Disconnect and remove work where indicated on the contract documents in its entirety.

B. Removal: Remove indicated equipment, piping, ductwork, insulation and associated components from Project site and dispose of in a legal manner. Provide owner’s right of first refusal for all equipment removed.

C. Where work is indicated to be abandoned in place, cut and remove pipe or ductwork a minimum of 2 inches (50 mm) beyond the wall, floor, ceiling or roof. Patch surface to match existing finish of adjacent construction.

D. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

3.9 REPAIRS

A. If existing or new work is damaged or disturbed, remove damaged sections and install new products of equal capacity and quality.

END OF SECTION
SECTION 230513 ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This section specifies the basic requirements for electrical components which are furnished with mechanical equipment (factory or field installed).

1.2 REFERENCES
A. NEMA Standards MG 1: Motors and Generators.
B. NEMA Standards ICS 2: Industrial Control Devices, Controllers, and Assemblies.
E. Comply with National Electrical Code (NFPA 70).

1.3 SUBMITTALS
A. Factory furnished electrical component product data submittal requirements are specified within the individual equipment specification sections.

1.4 QUALITY ASSURANCE
A. Electrical components and materials shall be UL or ETL labeled.

PART 2 - PRODUCTS

2.1 MOTORS
A. Electrical Characteristics shall meet the following unless otherwise indicated:

1. Frequency Rating: 60 HZ

2. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
   a. 120V circuit: 115V motor rating.
   b. 208V circuit: 200V motor rating.
   c. 240V circuit: 230V motor rating.
   d. 480V circuit: 460V motor rating.

B. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.

1. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

C. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors, unless otherwise indicated.

D. Temperature rating: Rated for 40°C (104°F) environment.
E. Temperature rise: Rated for maximum of 90°C (194°F) rise for continuous duty at full load, Class B insulation, except for inverter duty rated motors which shall use Class F insulation.

F. Starting capability: Frequency of starts as required to meet automatic control system sequence of operation, and not less than 5 evenly timed starts per hour.

G. Capacity: Sufficient to start and operate connected loads without exceeding name plate ratings.

   1. Bearings:
      b. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

   2. Mounting:
      a. Horizontal: foot mounted.

   3. Enclosure Type: See individual equipment specifications for enclosure type.

   4. Lifting Lug: lifting eye or lug for all motors exceeding 50 pounds.

   5. Stamped Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, efficiency, special features and similar information.

   6. All motors 1hp and larger shall be premium efficiency, constant speed, rpm as specified, squirrel cage, unless otherwise required to meet driven equipment’s maximum starting duty. Minimum full-load nominal efficiencies per IEEE Standard 112, Test Method B shall be equal to or greater than those listed in the following tables.

I. Polyphase Motors:
   1. General: Squirrel-cage induction-type conforming to the following requirements except as otherwise indicated.

   2. Variable Speed Motors for Use With Solid-State Drives: Energy efficient, invertor ready, design B units with ratings, characteristics, and features coordinated with drive manufacturer.

   3. Bearings: Suitable for radial and thrust loading of the application.

   4. Severe Duty Motors: Minimum 1.25 service factor. Provide motors with regreaseable bearings and equipped with capped relief vents. Insulate windings with nonhygroscopic material.

   5. Motors for Reduced Inrush Starting: Coordinate with reduced inrush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.

J. Single-Phase Motors:
   1. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application.
a. Permanent Split Capacitor.
b. Split-Phase Start, Capacitor-Run
c. Capacitor-Start, Capacitor-Run
d. Shaded-Pole.
e. Capacitor Start, Induction Run.

2. Internal Thermal Overload Protection for Motors: Protection shall automatically open the power supply circuit to the motor, or a control circuit. Protection shall operate when winding temperature exceeds a safe value calibrated to the temperature rating of the motor insulation. Motor shall automatically reset when motor temperature returns to normal range.

3. Bearings: Belt connected motors or other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, prelubricated sleeve bearings may be used for other single phase motors.

2.2 STARTERS, DISCONNECTS AND ACCESSORIES

A. Motor Starter Characteristics:

1. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition. Minimum size starter shall be NEMA Size 1.

B. Manual Disconnect Switches:

1. Fusible switches: fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the “OPEN” position; arc quenchers; capacity and characteristics as required by equipment manufacturer.

2. Non-fusible switches: horsepower rated toggle switch type; quantity of poles and voltage rating as required by equipment manufacturer.

C. Magnetic Starters:

1. Hand-off-auto, selector switches and pilot lights.

2. Trip-free thermal overload relays, each phase.

3. Interlocks, switches, contacts and similar devices as required for coordination with control requirements.

4. Built-in control circuit transformer, sized by manufacturer. Provide with minimum two normally-open and two normally closed spare auxiliary contacts.

5. Externally operated manual reset.

6. High voltage and low voltage protection in all three phases.

7. Internal Thermal Overload Protection for Motors: Protection shall automatically open control circuit. Protection shall operate when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.
D. Starter Enclosures:

1. NEMA rated as required for environment in which equipment is to be installed.
2. Interlock covers of combination starters with operating handle providing access to inside of enclosure only when disconnect is in “OFF” position. Provide means to attach multiple padlocks for locking external operating handle in either the “ON” or “OFF” position.
3. Provide red colored RESET Button in cover of starter.
4. Provide and secure wiring diagram corresponding to motor and control wiring of associated equipment on inside of each magnetic and combination starter.
5. Manual starter shall have means for externally locking operating mechanism in “OFF” position.

E. Factory Installed Motor Connections:

1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Motors: Install field-installed motors in accordance with manufacturer’s published instructions and the following:

1. Direct Connected Motors: Mount securely in accurate laser alignment.
2. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.

B. Motor Controllers (starters, Disconnects and Drives): Install field-installed starters, disconnects and drives in accordance with manufacturer’s published instructions and the following:

1. Locate controllers within sight of motors controller.
2. Mounting: For control equipment at walls, bolt units to wall or mount on light-weight structural steel channels bolted to the wall. For controllers not at walls, provide freestanding racks fabricated of structural steel members and light-weight slotted structural steel channels. Use feet consisting of 3/8-inch thick steel plates, 6 inch square, bolted to the floor. Use feet for welded attachment of 1-1/2-inch thick steel plates, 6 inch square, bolted to the floor. Use feet for welded attachment of 1-1/2-inch by 1-1/2-inch by 1/4 inch vertical angle pots not over three feet on centers. Connect the posts with horizontal lightweight slotted steel channels and bolt the control equipment to the channels.
3. Clearances: All motor controllers shall be installed per NEC requirements.
3.2 ACCEPTANCE

A. The right is reserved by the Owner’s Representative to reject any motor which, in his opinion, either under test or in actual service is found to be overloaded, develops excessive mechanical noise, magnetic hum, or otherwise operates unsatisfactorily, within the speed range and load specified. The contractor shall adjust, or if necessary replace any such deflected motor with one satisfactory to the Owner or Owner’s Representative without any extra cost to the Owner.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe expansion joints, guides, and anchors for mechanical piping systems.

1.2 PERFORMANCE REQUIREMENTS

A. Compatibility: Provide pipe expansion joints, pipe alignment guides, and pipe anchors suitable for piping system fluids, materials, working pressures, and temperatures.

B. Fabricate and install expansion and anchor system capable of sustaining forces generated by gravity and thermal movement.

1.3 SUBMITTALS

A. Product data for each type of pipe expansion joint and pipe alignment guide specified.

B. Pipe expansion joint schedule showing manufacturer’s figure number, size, location and features for each required expansion joint.

C. Assembly-type shop drawings for each type of pipe expansion joint, pipe alignment guide, and anchor, indicating dimensions, weights, required clearances, and methods of component assembly.

D. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the “Quality Assurance” Article.

E. Maintenance data for each type pipe expansion joint specified to include in the “Operating and Maintenance Manuals”.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators according to AWS D1.1 “Structural Welding Code-Steel.”

   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators according to ASME “Boiler and Pressure Vessel Code,” Section IX, “Welding and Brazing Qualifications”

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   1. Metal-Bellows, Packless-Type Pipe Expansion Joints:
      a. Adsco Manufacturing Corp.
      b. Anamet, Inc.
      c. Badger Industries, Inc.
      d. Hyspan Precision Products, Inc.
e. Keflex, Inc.
f. Metraflex Co.
g. Pathway Bellows, Inc., Dover Corp.
h. Piping Technology & Products, Inc.
i. Proco Products, Inc.
j. Senior Flexonics Inc., Expansion Joint Div.

2. Pre-fabricated Flexible Expansion Loops
   a. The Metraflex, Co. – “Metraloop”.
   b. Or Approved Equal.

3. Pipe Alignment Guides:
   a. Adsco Manufacturing Corp.
   b. Advanced Thermal Systems, Inc.
   c. B-Line Systems, Inc.
   e. Hyspan Precision Products, Inc.
   f. Keflex, Inc.
   g. Metraflex Co.

2.2 PIPE EXPANSION JOINTS, GENERAL
   A. Capability: Absorb 200 percent of maximum piping expansion between anchors.

2.3 PACKLESS-TYPE PIPE EXPANSION JOINTS
   A. Metal-Bellows Packless-Type Pipe Expansion Joints: Pressure rated for 175 psig (1200 kPa) minimum; conform to the standards of Expansion Joint Manufacturers Association, Inc. (EJMA); with end fittings and external tie rods for limiting maximum travel. Features include the following:

2.4 PRE-FABRICATED FLEXIBLE EXPANSION LOOPS
   A. Flexible loops shall be (Stainless Steel hose and braid - with threaded or weld ends) or (Bronze hose hose and braid - with copper sweat ends) or (Stainless Steel hose and braid with 150 lb. Flanged, weld or grooved ends). Flexible loops shall be designed to impart no thrust loads on the anchors. The loop shall consist of two flexible sections of hose and braid, two 90 deg. Elbows, and a 180 deg. Return. Loops shall be installed in a neutral, precompressed or preextended condition as required for the application. Install loops, anchors (anchors for thrust loads shall not be required) and guides as per manufacturer’s installation instructions and recommendations.

2.5 PIPE ALIGNMENT GUIDES
   A. Factory-fabricated cast semisteel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base. Include two-section guiding spider that bolts tightly to the pipe.

2.6 MISCELLANEOUS MATERIALS
   A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
   B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.
   C. Washers: ASTM F 844, steel, plain, flat washers.
D. Powder-Actuated Fasteners: Attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
   1. Powder-actuated fasteners shall not be use in lightweight concrete or concrete slabs less than 4” thick.

E. Concrete: Portland-cement mix, 3000 psi (20.7 MPa).
   1. Cement: ASTM C 150, Type I.

F. Grout: ASTM C 1107, Grade B, nonshrink, nonmetallic.
   1. Characteristics include post-hardening volume-adjusting dry hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.
   2. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine substrates and conditions under which pipe expansion joints, pipe alignment guides, and pipe anchors are to be installed. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE EXPANSION JOINT INSTALLATION
   A. Install pipe expansion joints according to manufacturer’s written instructions.
   B. Align expansion joints to avoid end-loading and torsional stress.

3.3 FABRICATED-TYPE PIPE EXPANSION COMPENSATION INSTALLATION
   A. Install pipe expansion loops cold-sprung in tension or compression as required to absorb 50 percent of total compression or tension that will be produced during anticipated change in temperature.
   B. Connect risers to mains with at least 5 pipe fittings including tee in main.
   C. Connect risers to terminal units with at least 4 pipe fittings including tee in riser.

3.4 PIPE ALIGNMENT GUIDE INSTALLATION
   A. Install pipe alignment guides on piping that adjoins pipe expansion joints per the pipe expansion joint manufacturer’s written instructions.
   B. Install pipe alignment guides on piping that adjoins pipe expansion loops.
   C. Install pipe alignment guides on piping elsewhere as indicated.
   D. Secure pipe alignment guides to building substrate.
3.5 PIPE ANCHOR INSTALLATION

A. Install pipe anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS D1.1.

C. Construct concrete pipe anchors of poured-in-place concrete of dimensions indicated.

D. Where pipe expansion joints are indicated, install pipe anchors according to expansion unit manufacturer’s written instructions to control movement to compensators.

E. Pipe Anchor Spacings: Where not otherwise indicated, install pipe anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Preset anchors as required to accommodate both expansion and contraction of piping.

F. Use grout to form flat bearing surfaces for pipe expansion joints, pipe alignment guides, and pipe anchors that are installed on or in concrete.

3.6 FIELD QUALITY CONTROL

A. Licensed Engineer’s Installation Report: Prepare report covering installation of pipe expansion joints, pipe alignment guides, and pipe anchors. Include seal and signature of Registered Engineer, licensed in jurisdiction where Project is located, certifying compliance with specifications.

END OF SECTION
SECTION 230519 METERS AND GAGES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of meters and gages:
   1. Temperature gages and fittings.
   2. Pressure gages and fittings.
   3. Flow meters.

1.2 SUBMITTALS

A. Product data for each type of meter and gage. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gage schedule showing manufacturer’s figure number, scale range, location, and accessories for each meter and gage.

B. Product certificates signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and products’ compliance with specified requirements.

C. Maintenance data for each type of meter and gage.

1.3 QUALITY ASSURANCE

A. UL Compliance: Comply with applicable UL standards pertaining to meters and gages.

B. ASME and ISA Compliance: Comply with applicable portions of ASME and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Insertion Liquid-In-Glass Thermometers:
   1. Marshalltown Instruments, Inc.
   2. Trerice (H.O.) Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Corp.

B. Direct-Mount Filled-System Dial Thermometers:
   3. Trerice (H.O.) Co.
   4. Weiss Instruments, Inc.
   5. Weksler Instruments Corp.

C. Thermometer Wells: Same as for thermometers.
D. Insertion Dial Thermometers:

2. Tel-Tru Manufacturing Co., Inc.
3. Trerice (H.O.) Co.
4. Weiss Instruments, Inc.
5. Weksler Instruments Corp.

E. Pressure Gages:

4. Marshalltown Instruments, Inc.
5. Trerice (H.O.) Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Corp.
8. WIKA Instruments Corp.

F. Pressure Gage Accessories: Same as for pressure gages.

G. Water Orifice-Type Measurement System:

1. Armstrong Pumps, Inc.
2. Bell & Gossett, ITT, Fluid Handling Div.

H. BTU Meters:

1. Data Industries Corp.
2. ISTA Energy Systems Corp.
4. QMI.

I. Test Plugs:

1. MG Piping Products Co.
2. Peterson Equipment Co., Inc.
4. Trerice (H.O.) Co.
5. Watts Regulator Co.

2.2 THERMOMETERS, GENERAL

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

B. Scale range: Temperature ranges for services listed as follows:

1. General: Temperature range shall be selected such that normal operating temperature is at 75% of scale.

2. Domestic Cold Water: 0 to 100°F with 2-degree scale divisions (minus 18 to 38°C with 1-degree scale divisions).
3. **Hot Water:** 30 to 300°F with 2-degree scale divisions (0 to 150°C with 1-degree scale divisions).

4. **Condensed Water:** 0 to 160°F with 2-degree scale divisions (minus 18 to 70°C with 1-degree scale divisions).

5. **Chilled Water:** 0 to 100°F with 2-degree scale divisions (minus 18 to 38°C with 1-degree scale divisions).

### 2.3 INSERTION LIQUID-IN-GLASS THERMOMETERS

A. **Case:** Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

B. **Adjustable Joint:** Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

C. **Tube:** Red reading, mercury-free liquid filled, magnifying lens.

D. **Scale:** Satin-faced, nonreflective aluminum, with permanently etched markings.

E. **Stem:** Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

### 2.4 DIRECT-MOUNT FILLED-SYSTEM DIAL THERMOMETERS

A. **Type:** Vapor actuated, universal angle.

B. **Case:** Drawn steel or cast aluminum, glass lens, 4-1/2-inch diameter.

C. **Adjustable Joint:** Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. **Thermal Bulb:** Copper with phosphor bronze bourdon pressure tube.

E. **Movement:** Brass, precision geared.

F. **Scale:** Progressive, satin faced, nonreflective aluminum, permanently etched markings.

G. **Stem:** Copper-plated steel, aluminum, or brass, for separable socket, length to suit installation.

### 2.5 DIAL-TYPE INSERTION THERMOMETERS

A. **Type:** Bimetal, stainless steel case and stem, 1-inch-diameter dial, dust- and leakproof, 1/8-inch-diameter tapered-end stem with nominal length of 5 inches.

### 2.6 THERMOMETER WELLS

A. **Thermometer Wells:** Brass or stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

### 2.7 PRESSURE GAGES

A. **Type:** General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection.
B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:
   1. Vacuum: 30 inches Hg to 15 psi.
   2. All fluids: 2 times operating pressure.

2.8 PRESSURE GAGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.9 FLOW METERS, GENERAL

A. Flow rate of elements and meters shall be same as connected equipment or system.

2.10 WAFER ORIFICE-TYPE FLOOD ELEMENTS

A. Type: Differential-pressure wafer-type orifice insert flow elements designed for installation between pipe flanges.

B. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate. Elements shall be pressure rated for 300 psig and 250°F (120°C).

2.11 METERS

A. Permanently Mounted Meters: Suitable for mounting on wall or bracket, 6-inch dial or equivalent with fittings and copper tubing for connecting to flow element.

B. Scale shall be in gpm unless otherwise indicated.

C. Accuracy: Plus or minus 1 percent between 20 to 80 percent of range.

D. Portable Meters: Differential-pressure gage and two 12-foot hoses in carrying case with handle.

E. Scale: In inches of water unless otherwise indicated.

F. Accuracy: Plus or minus 2 percent between 20 to 80 percent of range.

G. Each meter shall be complete with operating instructions.

2.12 BTU METERS

A. Type: BTU meters consisting of turbine wheel flow meter, 2 temperature sensors, solid-state calculator with integral battery pack, integral stop valves, strainer, and magnetic trap.
B. Construction: Bronze housing, 125 psig rating.

C. Temperature Ranges: 40 to 250°F (5 to 120°C).

D. Data Output: 6-digit electromechanical counter with readout in KWH or BTU.

E. Accuracy: Plus or minus 1 percent.

F. Battery Pack: 5-year lithium battery.

2.13 TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

2. Air and Water, minus 30 to 275°F (minus 35 to 136°C): EPDM.

C. Test Kit: Provide test kit consisting of 1 pressure gage, gage adapter with probe, 2 bimetal dial thermometers, and carrying case.

D. Ranges of pressure gage and thermometers shall be approximately 2 times systems operating conditions.

PART 3 - EXECUTION

3.1 THERMOMETERS INSTALLATION

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install in the following locations and elsewhere as indicated:

1. At inlet and outlet of each hydronic zone.
2. At inlet and outlet of each hydronic boiler and chiller.
3. At inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. At inlet and outlet of each hydronic heat exchanger.
5. At inlet and outlet of each hydronic heat recovery unit.

C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

3.2 INSTALLATION OF PRESSURE GAGES

A. Install pressure gages in piping tee with pressure gage valve, located on pipe at most readable position.

B. Install in the following locations, and elsewhere as indicated:

1. At suction and discharge of each pump.
2. At discharge of each pressure-reducing valve.
3. At building water service entrance.
4. At chilled water and condenser water inlets and outlets of chillers.

C. Pressure Gage Needle Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.3 INSTALLATION OF TEST PLUGS

A. Test Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 INSTALLATION OF FLOW-MEASURING ELEMENTS AND METERS

A. General: Install flow meters for piping systems located in accessible locations at most readable position.

B. Locations: Install flow measuring meters and associated flow elements in the locations shown or indicated elsewhere as indicated.

C. Differential-Pressure-Type Flow Elements: Install minimum straight lengths of pipe upstream and downstream from element as prescribed by the manufacturer’s installation instructions.

D. Install wafer orifice-type element between 2 Class 125 pipe flanges, ANSI B16.1 (cast iron) or ANSI B16.24 (bronze).

E. Meters For Use With Flow Elements: Install meters on wall or bracket in accessible location.

F. Install connections, tubing, and accessories between flow elements and meters as prescribed by the manufacturer’s installation instructions.

G. BTU Meters: Install in piping where indicated in hydronic supply line. Install thermal well in return line for remote sensor. Mount meter on wall if accessible; if not, provide bracket to support meter.

3.5 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer’s touch-up paint.

3.6 CONNECTIONS

A. Piping installation requirements are specified in other sections. The drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install meters and gages piping adjacent to machine to allow servicing and maintaining of machine.

END OF SECTION
SECTION 230523 VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: This section includes general duty valves common to most mechanical piping systems. Special purpose valves are specified in individual piping system specifications.

1.2 SUBMITTALS

A. Product Data: Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances.

B. Valve Schedule: Valve schedule indicating manufacturer’s figure number, size, location, and valve features for each required valve, and installation instructions.

1.3 QUALITY ASSURANCE

A. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.4 STORAGE AND HANDLING

A. Storage: Use the following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

B. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the manufacturers listed in valve schedule.

B. Provide valves of same manufacturer throughout where possible. Manufacturer’s name, valve size, and pressure rating shall be clearly marked on outside of body.
2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.
   1. Non-rising stem valves may be used where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:
   1. Handwheels, fastened to valve stem, for valves other than quarter turn.
   2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves.
   3. Chain-wheel operators, for valves 2-1/2-inch and larger, install 72 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.
   4. Gear drive operators, on quarter-turn valves 8-inch and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.
      a. Caution: Where brazed end connections are used, use solder having a melting point below 840EF for gate, globe, and check valves; below 421EF for ball valves.

2.3 BALL VALVES

A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 600 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable “Teflon” or “TFE” seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water.

B. Ball Valves, 1-1/4-Inch to 2 Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, full port, stainless steel ball, replaceable “Teflon” or “TFE” seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for condenser water, chilled water, and domestic hot and cold water service; threaded ends for heating hot water and low-pressure steam.

C. Ball Valves, 2-1/2-Inch and Up: Rated for 150 psi saturated steam pressure, 400 psi WDG pressure; 3 piece construction; with carbon steel body conforming to ASTM-A216 WCB, full port, stainless steel
ball, replaceable “Teflon” or “TFE” seats and seals, blowout proof stem, and vinyl covered steel handle - flanged ends.

2.4 PLUG VALVES

A. Plug Valves, 2-Inch and Smaller: Rated at 150 psi WOG; bronze body, with straightaway pattern, square head, and threaded ends.

B. Plug Valves, 2-1/2-Inch and Larger: MSS SP-78; rated at 175 psi WOG; lubricated plug type, with semisteel body, single gland, wrench operated, and flanged ends.

2.5 GLOBE VALVES

A. Globe and Globe Angle Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, “Teflon” impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe and Globe Angle Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze mounted, flanged ends, and “Teflon” impregnated packing, and two-piece backing gland assembly.

2.6 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks for sizes 2 through 6 inches and gear operators with position indicator for sizes 8 through 24 inches. [Provide full lug type body; drilled and tapped valves for dead-end service unless otherwise specified.]

2.7 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

B. Swing Check Valves, 2-1/2-Inch and Larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

PART 3 - EXECUTION

3.1 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Brazed ends, except provide threaded ends for heating hot water and low-pressure steam service. Provide C-MIP adapters for service end valves for copper hot water heating system piping.
2. Steel Pipe Sizes, 2-Inch and Smaller: threaded or grooved end.

3. Steel Pipe Sizes 2-1/2 Inch and Larger: grooved end or flanged.

3.2 VALVE INSTALLATIONS

A. General Application: Use ball, and butterfly valves for shut-off duty; globe, ball and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.

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

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install balance valves in the return piping of all water coils and/or where shown on the drawings.

E. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

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

G. Install valves in a position to allow full stem movement.

H. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Horizontal position with hinge pin level.

I. Install access doors in ceilings or walls as required in the types and sizes to accommodate easy valve access and construction (sheet rock, etc. and fire rating).

3.3 BRAZED CONNECTIONS

A. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 FLANGED CONNECTIONS

A. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.5 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.6 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.
3.7 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

### VALVES, 2-INCH AND SMALLER

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>GATE</th>
<th>GLOBE</th>
<th>BALL</th>
<th>CHECK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condenser Water</td>
<td>125</td>
<td>125</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>125</td>
<td>125</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td>Heating Hot Water</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

### VALVES, 2-1/2-INCH AND LARGER

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>GATE</th>
<th>GLOBE</th>
<th>BUTTERFLY</th>
<th>CHECK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condenser Water</td>
<td>125</td>
<td>125</td>
<td>200</td>
<td>125</td>
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<tr>
<td>Chilled Water</td>
<td>125</td>
<td>125</td>
<td>200</td>
<td>125</td>
</tr>
<tr>
<td>Heating Hot Water</td>
<td>125</td>
<td>125</td>
<td>200</td>
<td>125</td>
</tr>
</tbody>
</table>

3.8 VALVE SCHEDULE

A. Ball Valves - 1 Inch and Smaller:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>THREADED ENDS</th>
<th>SOLDER ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conbraco (Apollo)</td>
<td>70-100</td>
<td>70-200</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>BA-100</td>
<td>BA-150</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-585-70</td>
<td>S-585-70</td>
</tr>
</tbody>
</table>

B. Ball Valves - 1-1/4 Inch to 2 Inch:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>THREADED ENDS</th>
<th>SOLDER ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conbraco (Apollo)</td>
<td>82-100</td>
<td>82-200</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>300S</td>
<td>350S</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-590-Y</td>
<td>S-590-Y</td>
</tr>
</tbody>
</table>

1. For grooved end connections, use Victaulic Style 721.

2. For ball valves 2-1/2" and up - flanged carbon steel with stainless steel trim - Milwaukee - F90CS 150R-02 or approved equal.

C. Plug Valves - 2 Inch and Smaller:

1. Resun: R-1430 or approved equal.

D. Plug Valves - 2-1/2 Inch and Larger:

1. Resun: R-1431 or approved equal.

E. Globe Valves - 2 Inch and Smaller:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>CLASS 125 THREADED</th>
<th>CLASS 125 SOLDER</th>
<th>CLASS 150 THREADED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>502</td>
<td>1502</td>
<td>590</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-211-B</td>
<td>S-211-B</td>
<td>T-235-Y</td>
</tr>
<tr>
<td></td>
<td>T-211-Y</td>
<td>S-211-Y</td>
<td></td>
</tr>
<tr>
<td>Stockham</td>
<td>B16</td>
<td>B14T</td>
<td>B-22</td>
</tr>
</tbody>
</table>
F. Globe Valves - 2-1/2 Inch and Larger:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>STRAIGHT BODY</th>
<th>ANGLE BODY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>F2981</td>
<td>F2989</td>
</tr>
<tr>
<td>Nibco</td>
<td>F-718-B</td>
<td>F-818-B</td>
</tr>
<tr>
<td>Stockham</td>
<td>G-512</td>
<td>G-515</td>
</tr>
</tbody>
</table>

G. Butterfly Valves - 2-1/2 Inch and Larger: Wafer type.

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>CW-223E-B</td>
<td>CW-323E-B</td>
</tr>
<tr>
<td>Nibco</td>
<td>WD-20103</td>
<td>WD-20105</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-04-111-11</td>
<td>BF-04-111-12</td>
</tr>
</tbody>
</table>

Note: Wafer type valves are to be used only when specifically indicated as approved for use, otherwise use lug type as standard.

1. The following are model numbers for lug-type, with nickel-plated ductile-iron disc:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>ML-222-E</td>
<td>ML-322-E</td>
</tr>
<tr>
<td>Nibco</td>
<td>LD-20103</td>
<td>LD-20105</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-03-111-11</td>
<td>BF-03-111-12</td>
</tr>
</tbody>
</table>

2. Grooved Ends: Victaulic Series 300, 700 AND 704.
   Milwaukee GG-245-9 and GG-345-9.

3. The following are model numbers for lug-type, with aluminum-bronze disc:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>LEVER</th>
<th>GEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>ML-223-E</td>
<td>ML-323-E</td>
</tr>
<tr>
<td>Nibco</td>
<td>LD-20003</td>
<td>LD-20005</td>
</tr>
<tr>
<td>Watts</td>
<td>BF-03-121-11</td>
<td>BF-03-121-12</td>
</tr>
</tbody>
</table>

   Milwaukee GG-245-9 and GG-345-9.

H. Swing Check Valves - 2 Inch and Smaller:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>CLASS 125 THREADED ENDS</th>
<th>CLASS 125 SOLDER ENDS</th>
<th>CLASS 150 THREADED ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>509</td>
<td>1509</td>
<td>510</td>
</tr>
<tr>
<td>Nibco</td>
<td>T-413</td>
<td>S-413</td>
<td>T-433</td>
</tr>
<tr>
<td>Stockham</td>
<td>B-319</td>
<td>B-309</td>
<td>B-321</td>
</tr>
</tbody>
</table>

1. For grooved connections, use Victaulic Series 712.

I. Swing Check Valves - 2-1/2 Inch and Larger:

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>CLASS 125</th>
<th>CLASS 175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milwaukee</td>
<td>F2974</td>
<td>F-2974-FP</td>
</tr>
<tr>
<td>Nibco</td>
<td>F-918</td>
<td>X</td>
</tr>
<tr>
<td>Stockham</td>
<td>G-931</td>
<td>G-940</td>
</tr>
</tbody>
</table>
1. For grooved connections, use Victaulic Series 712.
2. X means not available.

J. Cast Steel Globe Valves - 2-1/2" and up: Milwaukee, Powell, or equal:

<table>
<thead>
<tr>
<th>Description 300 PSIG</th>
<th>MILWAUKEE</th>
<th>POWELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanged</td>
<td>3060</td>
<td>3031 F</td>
</tr>
<tr>
<td>Buttweld</td>
<td>3065</td>
<td>3031 WE</td>
</tr>
</tbody>
</table>

Note: Provide valves with forged steel, socket weld by-pass assemblies - sizes same as indicated under item AP@ above.

K. Cast Steel Swing Check Valves - 2-1/2" and up: Milwaukee

<table>
<thead>
<tr>
<th>Description 300 PSIG</th>
<th>MILWAUKEE</th>
<th>POWELL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanged</td>
<td>3070</td>
<td>3061 A-F</td>
</tr>
<tr>
<td>Buttweld</td>
<td>3075</td>
<td>3061 A-WE</td>
</tr>
</tbody>
</table>

L. Forged Steel Socket Weld Valves rated @ 800 PSIG and 850EF. - 2" and down: Smith Valve Co. or approved equal.

<table>
<thead>
<tr>
<th>Description</th>
<th>Smith Valve No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Socket Weld Gate Valve - OS&amp;Y</td>
<td>#G-80</td>
</tr>
<tr>
<td>2. Socket Weld Globe Valve -</td>
<td>#G-85</td>
</tr>
<tr>
<td>3. Socket Weld Check Valve</td>
<td>#C-80</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 230529 SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies mechanical hangers, support and anchors and includes the following:

1. Horizontal-piping hangers and supports.
2. Vertical-piping clamps.
3. Hanger-rod attachments.
4. Building attachments.
5. Saddles and shields.
6. Spring hangers and supports.
7. Miscellaneous materials.
8. Pipe alignment guides.
10. Equipment supports.

1.2 SUBMITTALS

A. Product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer’s figure number, size, location, and features for each required pipe hanger and support.

B. Assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. Details of trapeze hangers and upper attachments for piping 4 inches in diameter and over. Include the number and size of pipe lines to be supported on each type of trapeze hanger.

D. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the “Quality Assurance” Article.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Hangers and supports shall comply with NFPA standard No. 13 when used as a component of a fire protection system.

B. MSS Compliance: Provide hangers, supports and components conforming to the latest requirements of MSS Standard Practices SP-58 and SP-69.

C. Qualify welding processes and welding operators according to AWS D1.1 “Structural Welding Code-Steel.”

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

D. Qualify welding processes and welding operators according to ASME “Boiler and Pressure Vessel Code,” Section IX, “Welding and Brazing Qualifications.”

E. Listing and Labeling: Provide hangers and supports that are listed and labeled as defined in NFPA 70, Article 100.
1. UL and FM Compliance: Hangers, supports, and components include listing and labeling by UL and FM where used for fire protection piping systems.

2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.

1. Components include galvanized coatings where installed for piping and equipment that will not have a field-applied finish.

2. Pipe attachments include nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Thermal-Hanger Shield Inserts: 100-psi (690kPa) average compressive strength, waterproofed calcium silicate, encased with sheet metal shield. Insert and shield cover entire circumference of pipe and are of length indicated by manufacturer for pipe size and thickness of insulation.

C. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used; for use with minimum 4” thick heavyweight concrete slabs or greater. Fasteners for fire protection systems include UL listing and FM approval.

D. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval.

2.2 PIPE HANGERS AND SUPPORTS

A. Pipe Insulation Shields: Fabricated of steel, with a minimum of 180 degrees, unless otherwise indicated. Shields for use with hangers and supports, with the exception of combination clevis type hangers, shall be in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Pipe or Tubing Size (inches)</th>
<th>Shield Length (inches)</th>
<th>Shield Gage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 2</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>3 &amp; 4</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>8 &amp; up</td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>

B. Pipe Covering Protection Saddles: 3/16 inch thick steel, of sufficient depth for the insulation thickness specified, notched so that saddle contact with the pipe is approximately 50 percent of the total axial cross section. Saddles for pipe 12 inches in size and larger shall have a center support.

C. Pipe Hangers: Height adjustable standard duty clevis type, with cross bolt and nut. Pipe spreaders or spacers shall be used on cross bolts of clevis hangers, when supporting piping 10 inches ips and larger.
D. Adjustable Floor Rests and Base Flanges: Steel.

E. Hanger Rods: Galvanized, mild low carbon steel, fully threaded with two nuts at each end for positioning rod and hanger, and locking each in place.

F. Riser Clamps: Malleable iron or steel.

G. Rollers: Cast Iron.

H. Restraints, Anchors, and Supports for Grooved End Piping System: As recommended by the grooved end fitting manufacturer.

2.3 FASTENERS

A. Sleeve Anchors (Group II, Type 3, Class 3): Molly’s Div./USM Corp. Parasleeve Series, Ramset’s Dynabolt Series, or Red Head/Phillips AN1405, HN-1614, FS-1411 Series.

B. Wedge Anchors (Zinc Plated, Group II, Type 4, Class 1): Hilti’s Kwik Bolt Series, Molly’s Div./USM Corp. Parabolt PB Series, Ramset’s Trubolt T Series, or Red Head/Phillips WS-3822.

C. Self-Drilling Anchors (Group III, Type 1): Ramset’s RD Series, or Red Head/Phillips Series S-14.

D. Non-Drilling Anchors (Group VIII, Type 1): Ramset’s Dynaset DS Series, Hilti’s HDI Series, or Red Head/Phillips J Series.

E. Stud Anchors (Group VIII, Type 2): Red Head/Phillips JS-38 Series.

F. Continuous Slotted Type Concrete Insert, Galvanized:

1. Load Rating 800 lbs/ft: Kindorf’s D-986.
2. Load Rating 1500 lbs/ft: Kindorf’s D-980.
3. Load Rating 3000 lbs/ft: Hohmann & Barnard’s Inc. Type CS-H.
4. Load Rating 4500 lbs/ft: Hohmann & Barnard’s Inc. Type CS-HD.

G. Threaded Type Concrete Insert: Galvanized ferrous castings, internally threaded to receive 3/4 inch dia. machine bolts.

H. Wedge Type Concrete Insert: Galvanized box-type ferrous castings, internally threaded to receive 3/4 inch bolts having special wedge shaped heads.

I. Bolts, Nuts, Washers, Lags, and Screws: Medium carbon steel; size and type to suit application; galvanized for high humidity locations, and treated wood; plain finish for other interior locations. Except where shown otherwise on the Drawings, furnish type, size, and grade required for proper installation of the Work.

2.4 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Grout: ASTM C 1107, Grade B, nonshrink, nonmetallic.
1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.

2. Design Mix: 5000-psi (34.5MPa), 28-day compressive strength.


E. Pipe Alignment Guides: Factory fabricated, of cast semisteel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe.

Length of guides: As recommended by manufacturer to allow indicated travel.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

B. Do not hang or support one pipe from another or from ductwork.

C. Support all insulated horizontal piping conveying refrigerants or other fluids below ambient temperature, by means of hangers or supports with insulation shields installed outside of the insulation.

D. Space hangers or supports for horizontal piping on maximum center distances as listed in the following hanger schedules, except as otherwise specified, or noted on the Drawings.

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Maximum Spacing (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Pipe</td>
<td>12</td>
</tr>
<tr>
<td>Copper tubing, 1-1/4” and smaller</td>
<td>6</td>
</tr>
<tr>
<td>Copper tubing, 1-1/2” and larger</td>
<td>10</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>12</td>
</tr>
</tbody>
</table>

E. For Steel Pipe Gas Lines: Space hangers or supports on maximum centers of 6 feet for 1/2 inch pipe size; 8 feet for 3/4 inch and 1 inch pipe sizes and 10 feet for 1-1/4 inch pipe size above.

F. For Grooved End Steel Pipe:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Maximum Spacing (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 and under</td>
<td>7</td>
</tr>
<tr>
<td>2 thru 4</td>
<td>10</td>
</tr>
<tr>
<td>5 and over</td>
<td>12</td>
</tr>
</tbody>
</table>
G. No pipe length shall be left unsupported between any two coupling joints.

H. For Directional Changes: Install a hanger or support close to the point of change of direction of all pipe runs in either a horizontal or vertical plane.

I. For Concentrated Loads: Install additional hangers or supports, spaced as required and directed, at locations where concentrated loads such as in-line pumps, valves, fittings or accessories occur, to support the concentrated loads.

J. For Branch Piping Runs and Runouts Over 5 feet in Length: Install a minimum of one hanger, and additional hangers if required by the hanger spacing schedules.

K. Parallel Piping Runs: Where several pipe lines run parallel in the same plane and in close proximity to each other, trapeze hangers may be submitted for approval. Base hanger spacing for trapeze type hangers on the smaller size of pipe being supported. Design the entire hanger assembly based on a safety factor of five, for the ultimate strength of the material being used.

L. Support floor drain traps from the overhead construction, with hangers of type and design as required and approved. Overhead supports are not required for floor drain traps installed directly below earth supported concrete floors.

M. Size hanger rods in accordance with the following:

<table>
<thead>
<tr>
<th>Pipe or Tubing Size (inches)</th>
<th>Single Rod Hanger Size (inches)</th>
<th>Double Rod Hanger Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pipe</td>
<td>Tubing</td>
</tr>
<tr>
<td>Up to 2 inches</td>
<td>3/8</td>
<td>1/4</td>
</tr>
<tr>
<td>2-1/2 and 3</td>
<td>1/2</td>
<td>3/8</td>
</tr>
<tr>
<td>4 and 5</td>
<td>5/8</td>
<td>1/2</td>
</tr>
<tr>
<td>6</td>
<td>3/4</td>
<td>1/2</td>
</tr>
<tr>
<td>8, 10 and 12</td>
<td>7/8</td>
<td>5/8</td>
</tr>
</tbody>
</table>

N. Secure hanger rods as follows: Install one nut under clevis, angle or steel member; one nut on top of clevis, angle or steel member; one nut inside insert or on top of upper hanger attachment and one nut and washer against insert or on lower side of upper hanger attachment. A total of four nuts are required for each road, two at upper hanger attachment and two at hanger.

O. Vertical Piping:

1. Support vertical risers of piping systems, by means of heavy duty hangers installed close to base of pipe risers, and by riser clamps with extension arms at intermediate floors, with the distance between clamps not to exceed 25 feet, unless otherwise specified. Support pipe risers in vertical shafts equivalent to the aforementioned. Install riser clamps above floor slabs, with the extension arms resting on floor slabs. Provide adequate clearances for risers that are subject to appreciable expansion and contraction, caused by operating temperature ranges.

2. Support extension arms of riser clamps, secured to risers to be insulated for cold service, 4 inches above floor slabs, to allow room for insulating and vapor sealing around riser clamps.

3. Install intermediate supports between riser clamps on a maximum 6 foot centers, for copper tubing risers 1-1/4” in size and smaller, installed in finished rooms or spaces other than mechanical equipment machine or steam service rooms, or penthouse mechanical equipment rooms.
4. Floor Supports: Install adjustable yoke rests with base flanges, for the support of piping, unless otherwise indicated on the Drawings. Install supports in a manner, which will not be detrimental to the building structure.

P. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts.

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

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

S. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9 “Building Services Piping” is not exceeded.

3.2 UPPER HANGER ATTACHMENTS

A. General:
1. In all cases, secure upper hanger attachments to overhead structural steel, steel bar joists, or other suitable structural members.
2. Do not attach hangers to steel decks which are not to receive concrete fill.
3. Do not attach hangers to precast concrete plank decks less than 2-3/4 inches thick.
4. Do not use flat bars or bent rods as upper hanger attachments.

B. Attachment to Steel Frame Construction: Provide intermediate structural steel members where required by pipe support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of five.
1. Do not use drive-on beam clamps.
2. Do not support piping over 4 inches in size from steel bar joists. Secure upper hanger attachments to steel bar joists at panel points of joists.
3. Do not drill holes in main structural steel members.
4. “C” clamp type of upper hanger attachments with restraining straps may be used as upper hanger attachments for the support of piping up to a maximum of 3 inches in size and a temperature from 50°F to 200°F.

C. Attachment to Concrete Filled Steel Deck (Total thickness, 2-1/2 inches or more): Where necessary, attach hangers to the deck with welding studs (except at roof decks), thru-bolts with fish plates or tee hangers. Do not support a load, in excess of 250 lbs from any single welded stud, and thru-bolts with fish plates or tee hangers shall not be used to support piping over 3 inches in size.
D. Attachment to Cast-In-Place Concrete:


2. Install powder-actuated drive-pin fasteners 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. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches (100 mm) thick.

3. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer’s written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches (100 mm) thick.

E. Attachment to Existing Cast-In-Place Concrete:

1. For piping up to a maximum of 4 inches in size, secure hangers to overhead construction with self-drilling type expansion shields and machine tools.

2. Secure hangers to wall or floor construction with single unit expansion shields or self-drilling type expansion shields and machine bolts.

3. Install powder-actuated drive-pin fasteners 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. Do not use in lightweight concrete slabs or in concrete slabs less than 4 inches (100 mm) thick.

F. Attachment to Cored Precast Concrete Decks (Flexicore, Dox Plank, Spancrete, etc): Secure attachments to structural steel wherever possible. When fill is applied over decks, thru-bolts and fish plates may be used to support piping up to a maximum of 4 inches in size; mechanically expanded rod hangers or toggle bolts may be installed in cells for the support of piping up to a maximum of 2-1/2 inches in size.

G. Attachment to Hollow Block or Tile Filled Concrete Decks: Secure hangers to structural steel wherever possible. Inserts may also be used by omitting a block and pouring a solid concrete block, with a cast-in-place insert where required.

H. Attachment to Waffle Type Concrete Decks: Provide cast-in-place inserts where required. When fill is applied over deck, thru-bolts and fish plates may be used.

I. Attachment to Wood Construction: Secure hangers to the sides (only) of wood members, by means of malleable iron side beam connectors, or malleable iron or steel side beam brackets. Do not secure hanger attachments to nailing strips resting on top of steel beams.

1. Secure side beam connectors to wood members with two No. 18 x 1-1/2 inch long wood screws, or two No. 16 x 1-1/2 inch long drive screws. Do not support piping over 1-1/2 inches in size from side beam connectors. Do not hammer in wood screws.

2. Secure side beam brackets to wood members with steel bolts or lag screws. Do not use lag screws in wooden members having a nominal thickness (beam face) under 2 inches in size. Install bolts or lag screws, in the sides of timber or a joist, at the mid-point or above, not less than 2-1/2 inches from the lower edge when supporting branch lines and not less than 3 inches from the lower edge when supporting mains. Install heavy gage steel washers under all nuts.
3. Secure side beam brackets to wooden beams or joists, with lag screws or bolts of size as follows:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Lag Screw Size (inches)</th>
<th>Bolt Diameter (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 and under</td>
<td>3/8 diam x 1-3/4</td>
<td>3/8</td>
</tr>
<tr>
<td>2-1/2 and 3</td>
<td>1/2 diam x 2</td>
<td>1/2</td>
</tr>
</tbody>
</table>

a. Do not support piping larger than 3 inches with lag screws. Predrill holes for lag screws 1/8 inch in diameter less than the root diameter of the lag screw thread.

b. The minimum width of the lower face of wood beams or joints in which lag screws of size as specified may be used is as follows:

<table>
<thead>
<tr>
<th>Lag Screw Diameter (inches)</th>
<th>Nominal Width of Beam Face (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>2</td>
</tr>
<tr>
<td>1/2</td>
<td>3</td>
</tr>
</tbody>
</table>

3.3 TRAPEZES

A. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A 36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

3.4 ANCHORS, RESTRAINTS, RIGID SUPPORTS, STAYS, AND SWAY BRACES

A. Install pipe anchors, restraints, and sway braces, at locations noted on the Drawings. Design anchors so as to permit piping to expand and contract freely in opposite directions, away from anchor points. Install anchors independent of all hangers and supports, and in a manner which will not affect the structural integrity of the building.

B. In grooved end piping systems, install restraints, anchors, and rigid supports as recommended by the manufacturer of the grooved end fittings to ensure proper support and alignment of the piping under operating and testing pressures (maximum hanger or support spacing as previously specified).

1. Horizontal piping: Maintain a constant pitch without sages, humps, or lateral deflections.

2. Branch piping: Install perpendicular to main piping and/or risers.

3. Vertical piping: Install in plumb without deflections.

4. Vertical piping: Support rigidly or anchored at both top and bottom, and wherever necessary to prevent movement and/or shearing forces at branch connections.

3.5 COMBINATION CLEVIS HANGER, PIPE INSULATION SHIELD, AND VAPOR BARRIER JACKETED HIGH DENSITY INSULATING SADDLES

A. Install a combination clevis hanger, pipe insulation shield and vapor barrier jacketed high density insulating saddles, at all points of support for piping or tubing to be insulated for cold service. Furnish companion high density vapor barrier jacketed saddle pieces, of the same material, thickness and length, for installation over the top 180 degree surface of pipe or tubing, at each point of support where an insulated clevis hanger is utilized.
3.6 PIPE INSULATION SHIELDS

A. Install a pipe insulation shield, at all points of support, for piping insulated with cold service insulation. Center shields on all hangers and supports, and install in such a manner so as not to cut, puncture or press into the insulation, or in any manner be detrimental to the vapor barrier.

3.7 PIPE COVERING PROTECTION SADDLES

A. Install pipe covering protection saddles at all points of support, for steel piping 6 inches in size and larger, insulated with hot service insulation. Weld saddles to piping to insure movement with pipe.

3.8 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer’s written instructions to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.9 INSTALLATION OF PIPE ALIGNMENT GUIDES

A. Install pipe alignment guides on piping that adjoins expansion joints and elsewhere as indicated.

B. Anchor to building substrate.

3.10 EQUIPMENT SUPPORTS

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

B. Grouting: Place grout under supports for piping and equipment.

3.11 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.

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

C. Ferrous Metals: Clean galvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with recommendations of the Steel Structure Painting Council.
1. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by the paint manufacturer, and touch up with the same primer as the shop coat.

D. Galvanized Surfaces: Clean galvanized surfaces with non-petroleum based solvents so that the surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

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

F. Field Welding: Comply with AWS D1.1 procedures for manual shielded metal-arc welding, appearance and quality of welds, methods used in correcting welding work, and 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 that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

3.12 ADJUSTING

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

END OF SECTION
SECTION 230533  ELECTRICAL HEAT TRACING FOR PIPELINES

PART 1 - GENERAL

1.1  SUMMARY
A.  This section includes electrical heat tracing.

1.2  SUBMITTALS
A.  Product data.
B.  Manufacturer’s installation instructions.

PART 2 - PRODUCTS

2.1  ACCEPTABLE MANUFACTURERS
A.  Raychem Corporation “XL Trace” or approved equal.

2.2  MATERIALS
A.  Self-regulating heater consisting of two (2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, and to be cut to length in the field. The heater shall be supplied with power connection, end seal, splice and tee kits.

B.  Cover: A radiation cross-linked modified polyolefin dielectric jacket.

C.  Regulation: Self-regulating factor of at least ninety (90) percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 40°F pipe temperature operation to 150°F pipe temperature operation.

D.  The heater shall operate on line voltages of 208 volts without the use of transformers.

E.  Control: Ambient-sensing thermostat (set at 40°F) with NEMA 4X enclosure, ten (10) foot stainless steel capillary with bulb. UL Listed. Thermostat to be Raychem AMC-F5 or equal.

F.  Accessories: Power connection, end seal, splice and tee kits shall be Raychem “XLK.”

PART 3 - EXECUTION

3.1  INSTALLATION
A.  Size heaters according to the table illustrated below. The required heater output rating is in watts per foot at 50EF. (Heater selection based on 1” fiberglass insulation on metal piping).
### PIPE SIZE

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>MINIMUM AMBIENT -10°F</th>
<th>TEMPERATURES -20°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch or less</td>
<td>5 watt</td>
<td>5 watt</td>
</tr>
<tr>
<td>4 inch</td>
<td>5 watt</td>
<td>5 watt</td>
</tr>
<tr>
<td>6 inch</td>
<td>8 watt</td>
<td>8 watt</td>
</tr>
</tbody>
</table>

B. Power Connection, end seal, splice and tee kits components shall be assembled in the field.

C. Apply the heater linearly on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or fiberglass tape.

D. Position bulb outside the building. Drill hole through wall of selected area in an inconspicuous location. Firmly attach bulb in place, using pipe strap and galvanized screws at a point as close to the bulb as possible. Run capillary tube along side pipe back to thermostat locations, taping every 12” with glass tape.

E. Apply “electric traced” signs to the outside of the thermal insulation.

#### 3.2 TESTS

A. After installation and before and after installing the thermal insulation, subject heat tracing to testing using a 1,000 VDC megger. Minimum insulation resistance shall be 20 to 1,000 megohms regardless of length.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes vibration isolators and vibration isolation bases.

B. Product Data: Indicate types, styles, materials and finishes for each type of isolator specified. Include load deflection curves.

C. Shop Drawings: Show designs and calculations, certified by a professional engineer, for the following:
   1. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.

1.2 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases that are similar to those indicated for this Project in material, design, and extent.

1.3 PROJECT CONDITIONS

A. Project seismic zone is 1 with a zone factor of 0.075.

B. Building Importance Factor: 1.5.

1.4 COORDINATION

A. Coordinate layout and installation of vibration isolation and seismic-restraint devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of concrete housekeeping and vibration isolation bases. Cast anchor-bolt inserts into base.

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

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. Amber/Booth Company, Inc.
   2. B-Line Systems, Inc.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation Co., Inc.

2.2 VIBRATION ISOLATORS

A. Isolator Pads: Oil and water resistant and factory cut to sizes that match requirements of the equipment supported.

1. Rubber Isolator Pads: Elastomer (neoprene or silicone) arranged in single or multiple layers and molded with a nonslip pattern and steel baseplates of sufficient stiffness to provide uniform loading over the pad area.

2. Load Range: From 10 to 50 psig (69 to 345 kPa) and a deflection not less than 0.08 inch per 1 inch (2 mm per 25 mm) of thickness. Do not exceed a loading of 50 psig (345 kPa).

B. Spring Isolators: Freestanding, laterally stable, open-spring-type isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 1.2 times the rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to a 1/4-inch (6-mm-) thick, rubber isolator pad attached to the baseplate underside. Size baseplates to limit floor loading to 100 psig (690 kPa).

6. Top Plates: Provide threaded studs for fastening and leveling equipment.

7. Finishes: Manufacturer's standard corrosive-resistant finish.

C. Restrained Spring Isolators: Vertically restrained, freestanding, laterally stable, steel open-spring-type isolators.

1. Housing: Welded steel with resilient vertical limit stops to prevent spring extension due to wind loads or when weight is removed. Factory-drilled baseplate for bolting to structure and bonded to a 1/4-inch-(6-mm-) thick, rubber isolator pad attached to the baseplate underside. Provide adjustable equipment mounting and leveling bolt.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 0.8 times the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

D. Spring Hangers: Combination spring and elastomeric hanger with coil spring and elastomeric insert in compression.

1. Frame: Formed steel, fabricated for connection to threaded rods and to allow for 30 degrees of angular hanger rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

5. Finishes: Baked enamel for metal components. Color-code to indicate capacity range.

2.3 VIBRATION ISOLATION BASES

A. Fabricated Steel Bases: Structural-steel bases and rails designed and fabricated by the isolation equipment manufacturer. Include equipment static loadings, power transmission, component misalignment, and cantilever loadings.

1. Fabricate bases to shapes required, with welded structural-steel shapes, plates, and bars conforming to ASTM A 36 (ASTM A 36M). Include support brackets to anchor base to isolation units. Include prelocated equipment anchor bolts and auxiliary motor slide bases or rails.

2. Design and fabricate bases to result in the lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor.

3. Concrete-Filled Inertia Bases: Weld reinforcing bars to the structural frame. Pour concrete into base with relocated equipment anchor bolts.

4. Weld steel angles on frame for outrigger isolation mountings, and provide for anchor bolts and equipment support.

5. Configure inertia bases to accommodate equipment supported.

6. Pump Bases: Size to support pump and piping elbows.

7. Factory Finish: Manufacturer's standard corrosive-resistant finish.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and anchor vibration- and sound-control products according to manufacturer's written instructions and authorities having jurisdiction.

B. Anchor interior mounts, isolators, hangers, and snubbers to vibration isolation bases. Bolt isolator baseplates to structural floors as required by authorities having jurisdiction.
C. Anchor exterior mounts, isolators, hangers, and snubbers to vibration isolation bases. Bolt isolator baseplates to structural supports as required by authorities having jurisdiction.

D. Fill concrete inertia bases, after installing base frame, with 3000-psig (20.7-MPa) concrete, and trowel to a smooth, hard finish. Cast-in-place concrete is specified in Division 3.

E. Install pipe connectors at connections for equipment supported on vibration isolators.

3.2 ADJUSTING AND CLEANING

A. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operations.

B. Adjust thrust restraints for a maximum of 1/4 inch (6 mm) of movement at start and stop.

END OF SECTION
SECTION 230593 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly.
6. Reporting results of the activities and procedures specified in this Section.

1.2 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
E. Report Forms: Test data sheets for recording test data in logical order.
F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
K. Test: A procedure to determine quantitative performance of a system or equipment.
L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.


O. CTI: Cooling Tower Institute.

P. NEBB: National Environmental Balancing Bureau.

Q. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.3 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this Section.

C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

D. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

E. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Article below.

1.4 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by either AABC or NEBB.

B. Testing, Adjusting and Balancing Conference: Meet with the Owner's and the Engineer's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
   a. Submittal distribution requirements.
   c. Testing, adjusting, and balancing plan.
   d. Work schedule and Project site access requirements.
   e. Coordination and cooperation of trades and subcontractors.
   f. Coordination of documentation and communication flow.
C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.

2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.


F. Instrumentation Type, Quantity, and Accuracy: As described in AABC national standards.

G. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer. Provide copy of instrument certificates with final report.

1.5 PROJECT CONDITIONS

A. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after the required leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

A. General Warranty: The national project performance guarantee 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. Guarantee: Provide a guarantee on AABC'S "National Standards" forms stating that AABC will assist in completing the requirements of the Contract Documents or NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified Agent has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.
PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine equipment performance data, including fan and pump curves. 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.

D. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

E. Examine system and equipment test reports.

F. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

G. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

H. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

J. Examine strainers for clean screens and proper perforations, and remove temporary screens.

K. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to design values.

P. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness 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 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 design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
B. Cut insulation, ducts, and pipes, for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

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

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

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Verify that motor starters are equipped with properly sized thermal protection.

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

G. Check for airflow blockages.

H. Check condensate drains for proper connections and functioning.

I. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for other systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:
   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet, do not measure 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 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.

2. Measure static pressure across each air-handling unit component.
   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures.

5. Adjust fan speed to obtain design cfm. Replace or adjust to pulleys and electrical connections to accommodate fan-speed changes.

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 no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to within 10 percent of design airflow.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
   a. Where sufficient space in submains 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to within 10 percent of design airflows.

D. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

F. Adjust and balance system airflows to within 10 percent of design airflows.

3.6 VARIABLE-AIR-VOLUME SYSTEMS' ADDITIONAL PROCEDURES

A. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and 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 duct losses.

3. Measure total system airflow. Adjust to within 10 percent of design airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer’s written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units 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 as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets 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 adequate static pressure is maintained at the most critical unit.

8. Record the final fan performance data.

3.7 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

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

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.

2. Check expansion tank liquid level.

3. Check makeup-water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at design flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 HYDRONIC SYSTEMS' BALANCING PROCEDURES

A. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

1. Determine the balancing station with the highest percentage over design flow.

2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.

3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 VARIABLE-FLOW HYDRONIC SYSTEMS' ADDITIONAL PROCEDURES

A. Balance systems with automatic 2- and 3-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
3.10 PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS’ ADDITIONAL PROCEDURES

A. Balance the primary system crossover flow first, then balance the secondary system.

3.11 HEAT EXCHANGERS

A. Measure water flow through all circuits.
B. Adjust water flow to within specified tolerances.
C. Measure inlet and outlet water temperatures.
D. Measure inlet steam pressure. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves.
E. Record safety valve settings.
F. Verify operation of steam traps.

3.12 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   4. Efficiency rating of motor.
   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 for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.13 CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of design flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
   1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.
   2. Condenser water entering and leaving temperatures, pressure drop, and water flow.
   3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kW.
5. The kW input if factory-installed instrumentation is furnished for measuring kW.
7. Air-Cooled Chillers: Verify condenser-fan rotation and record fan data, including number of fans and entering- and leaving-air temperatures.

3.14 COOLING TOWERS

A. Shut off makeup water for the duration of the test, and then make sure the makeup and blow-down systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser water flow rate recirculating through the cooling tower.
6. Measure cooling tower pump discharge pressure.
7. Adjust water level and feed rate of makeup-water system.

3.15 CONDENSING UNITS

A. Verify proper rotation of fans and measure entering- and leaving-air temperatures. Record compressor data.

3.16 BOILERS

A. Measure and record entering- and leaving-water temperatures and water flow.

3.17 HEAT-TRANSFER COILS

A. Water Coils: Measure and record the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Wet-bulb temperatures of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.
3.18 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure and record indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied. Also measure and record outside air, wet- and dry-bulb temperatures concurrently with above.

3.19 SPRAY PAINTING FUME HOODS

A. Determine total airflow into the room where the fume hood is located and balance systems to ensure adequate air supply to all hoods.

1. Set fume-hood door opening at position of normal use.

2. Energize the exhaust fan and adjust airflow to provide the indicated average fume-hood face velocity at hood opening.

3. Measure exhaust airflow volume by measuring airflow by Pitot-tube duct traverse.


5. Record each face velocity measurement taken at 4- to 6-inch (100- to 150-mm) increments over the entire hood door opening.

6. Calculate the average face velocity by averaging all velocity measurements.

7. Calculate the airflow volume of exhaust-hood face velocity by multiplying the calculated average face velocity by the opening area. Compare this quantity with exhaust volume at exhaust fan and report duct leakage.

8. Measure airflow volume supplied by makeup fan. Verify that the makeup system supplies the proper amount of air to keep the space at the indicated pressure with the exhaust systems in all operating conditions.

9. Retest for average face velocity. Adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity and the indicated auxiliary air-supply percentages.

10. Retest and adjust the systems until fume-hood performance complies with Contract Documents.

3.20 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.
F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

G. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or non-grounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.21 TOLERANCES

A. Set HVAC system airflow and water flow rates within plus or minus 10 percent.

3.22 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, 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: As Work progresses, prepare 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.

3.23 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the 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, but do not include approved Shop Drawings and Product Data.
D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of testing, adjusting, and balancing Agent.
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 testing, adjusting, and balancing Agent who certifies the report.
10. Summary of contents, including the following:
    a. Design versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer, type size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from design values.
14. Test conditions for fans and pump performance forms, including the following:
    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings, including settings and percentage of maximum pitch diameter.
    e. Inlet vane settings for variable-air-volume systems.
    f. Settings for supply-air, static-pressure controller.
    g. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. **Unit Data:** Include the following:
   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 (mm), and bore.
   i. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.

2. **Motor Data:** Include the following:
   a. 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 (mm), and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

3. **Test Data:** Include design and actual values for the following:
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat coil static-pressure differential in inches wg (Pa).
   g. Cooling coil static-pressure differential in inches wg (Pa).
   h. Heating coil static-pressure differential in inches wg (Pa).
   i. Outside airflow in cfm (L/s).
   j. Return airflow in cfm (L/s).
   k. Outside-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. **Coil Data:** Include the following:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm o.c.).
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. **Test Data:** Include design and actual values for the following:
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).
o. Inlet steam pressure in psig (kPa).

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

1. Unit Data: Include the following:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btuh (kW).
   h. Ignition type.
   i. Burner-control types.
   j. Motor horsepower and rpm.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches (mm), and bore.
   n. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

2. Test Data: Include design and actual values for the following:
   a. Total airflow rate in cfm (L/s).
   b. Entering-air temperature in deg F (deg C).
   c. Leaving-air temperature in deg F (deg C).
   d. Air temperature differential in deg F (deg C).
   e. Entering-air static pressure in inches wg (Pa).
   f. Leaving-air static pressure in inches wg (Pa).
   g. Air static-pressure differential in inches wg (Pa).
   h. Low-fire fuel input in Btuh (kW).
   i. High-fire fuel input in Btuh (kW).
   j. Manifold pressure in psig (kPa).
   k. High-temperature-limit setting in deg F (deg C).
   l. Operating set point in Btuh (kW).
   m. Motor voltage at each connection.
   n. Motor amperage for each phase.
   o. Heating value of fuel in Btuh (kW).

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:
   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 (mm), and bore.
h. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).

2. Motor Data: Include the following:
   a. 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 (mm), and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
   g. Number of belts, make, and size.

3. Test Data: Include design and actual values for the following:
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Suction static pressure in inches wg (Pa).

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

1. Report Data: Include the following:
   a. System and air-handling unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F (deg C).
   d. Duct static pressure in inches wg (Pa).
   e. Duct size in inches (mm).
   f. Duct area in sq. ft. (sq. m).
   g. Design airflow rate in cfm (L/s).
   h. Design velocity in fpm (m/s).
   i. Actual airflow rate in cfm (L/s).
   j. Actual average velocity in fpm (m/s).
   k. Barometric pressure in psig (Pa).

K. Air-Terminal-Device Reports: For terminal units, include the following:

1. Unit Data: Include the following:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Test apparatus used.
   d. Area served.
   e. Air-terminal-device make.
   f. Air-terminal-device number from system diagram.
   g. Air-terminal-device type and model number.
   h. Air-terminal-device size.
   i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data: Include design and actual values for the following:
   a. Airflow rate in cfm (L/s).
   b. Air velocity in fpm (m/s).
   c. Preliminary airflow rate as needed in cfm (L/s).
   d. Preliminary velocity as needed in fpm (m/s).
   e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data: Include the following:
   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: Include design and actual values for the following:
   a. Airflow rate in cfm (L/s).
   b. Entering-water temperature in deg F (deg C).
   c. Leaving-water temperature in deg F (deg C).
   d. Water pressure drop in feet of head or psig (kPa).
   e. Entering-air temperature in deg F (deg C).
   f. Leaving-air temperature in deg F (deg C).

M. Packaged Chiller Reports: For each chiller, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Make and model number.
   c. Manufacturer's serial number.
   d. Refrigerant type and capacity in gal. (L).
   e. Starter type and size.
   f. Starter thermal protection size.

2. Condenser Test Data: Include design and actual values for the following:
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Entering-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).

3. Evaporator Test Reports: Include design and actual values for the following:
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Entering-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).

4. Compressor Test Data: Include design and actual values for the following:
   a. Make and model number.
   b. Manufacturer's serial number.
   c. Suction pressure in psig (kPa).
   d. Suction temperature in deg F (deg C).
   e. Discharge pressure in psig (kPa).
   f. Discharge temperature in deg F (deg C).
   g. Oil pressure in psig (kPa).
   h. Oil temperature in deg F (deg C).
   i. Voltage at each connection.
j. Amperage for each phase.
k. The kW input.
l. Crankcase heater kW.
m. Chilled water control set point in deg F (deg C).
n. Condenser water control set point in deg F (deg C).
o. Refrigerant low-pressure-cutoff set point in psig (kPa).
p. Refrigerant high-pressure-cutoff set point in psig (kPa).

5. Refrigerant Test Data: Include design and actual values for the following:
   a. Oil level.
   b. Refrigerant level.
   c. Relief valve setting in psig (kPa).
   d. Unloader set points in psig (kPa).
   e. Percentage of cylinders unloaded.
   f. Bearing temperatures in deg F (deg C).
   g. Vane position.
   h. Low-temperature-cutoff set point in deg F (deg C).

N. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Manufacturer's compressor serial numbers.
   e. Compressor make.
   f. Compressor model and serial numbers.
   g. Refrigerant weight in lb (kg).
   h. Low ambient temperature cutoff in deg F (deg C).

2. Test Data: Include design and actual values for the following:
   a. Inlet-duct static pressure in inches wg (Pa).
   b. Outlet-duct static pressure in inches wg (Pa).
   c. Entering-air, dry-bulb temperature in deg F (deg C).
   d. Leaving-air, dry-bulb temperature in deg F (deg C).
   e. Condenser entering-water temperature in deg F (deg C).
   f. Condenser leaving-water temperature in deg F (deg C).
   g. Condenser water temperature differential in deg F (deg C).
   h. Condenser entering-water pressure in feet of head or psig (kPa).
   i. Condenser leaving-water pressure in feet of head or psig (kPa).
   j. Condenser water pressure differential in feet of head or psig (kPa).
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig (kPa).
   n. High-pressure-cutout set point in psig (kPa).
   o. Suction pressure in psig (kPa).
   p. Suction temperature in deg F (deg C).
   q. Condenser refrigerant pressure in psig (kPa).
   r. Condenser refrigerant temperature in deg F (deg C).
   s. Oil pressure in psig (kPa).
   t. Oil temperature in deg F (deg C).
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. The kW input.
x. Crankcase heater kW.
y. Number of fans.
z. Condenser fan rpm.
aa. Condenser fan airflow rate in cfm (L/s).
bb. Condenser fan motor make, frame size, rpm, and horsepower.
c. Condenser fan motor voltage at each connection.
d. Condenser fan motor amperage for each phase.

O. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Make and type.
   c. Model and serial numbers.
   d. Nominal cooling capacity in tons (kW).
   e. Refrigerant type and weight in lb (kg).
   f. Water-treatment chemical feeder and chemical.
   g. Number and type of fans.
   h. Fan motor make, frame size, rpm, and horsepower.
   i. Fan motor voltage at each connection.
   j. Sheave make, size in inches (mm), and bore.
   k. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
   l. Number of belts, make, and size.

2. Pump Test Data: Include design and actual values for the following:
   a. Make and model number.
   b. Manufacturer's serial number.
   c. Motor make and frame size.
   d. Motor horsepower and rpm.
   e. Voltage at each connection.
   f. Amperage for each phase.
   g. Water flow rate in gpm (L/s).

3. Water Test Data: Include design and actual values for the following:
   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Water temperature differential in deg F (deg C).
   d. Entering-water pressure in feet of head or psig (kPa).
   e. Leaving-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).
   g. Water flow rate in gpm (L/s).
   h. Bleed water flow rate in gpm (L/s).

4. Air Data: Include design and actual values for the following:
   a. Duct airflow rate in cfm (L/s).
   b. Inlet-duct static pressure in inches wg (Pa).
   c. Outlet-duct static pressure in inches wg (Pa).
   d. Average entering-air, wet-bulb temperature in deg F (deg C).
   e. Average leaving-air, wet-bulb temperature in deg F (deg C).
   f. Ambient wet-bulb temperature in deg F (deg C).

P. Heat-Exchanger/Converter Test Reports: For hot-water heat exchangers, include the following:

1. Unit Data: Include the following:
a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Ratings.

2. **Primary Water Test Data:** Include design and actual values for the following:
   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Entering-water pressure in feet of head or psig (kPa).
   d. Water pressure differential in feet of head or psig (kPa).
   e. Water flow rate in gpm (L/s).

3. **Secondary Water Test Data:** Include design and actual values for the following:
   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Entering-water pressure in feet of head or psig (kPa).
   d. Water pressure differential in feet of head or psig (kPa).
   e. Water flow rate in gpm (L/s).

Q. **Pump Test Reports:** For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. **Unit Data:** Include the following:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model and serial numbers.
   f. Water flow rate in gpm (L/s).
   g. Water pressure differential in feet of head or psig (kPa).
   h. Required net positive suction head in feet of head or psig (kPa).
   i. Pump rpm.
   j. Impeller diameter in inches (mm).
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.

2. **Test Data:** Include design and actual values for the following:
   a. Static head in feet of head or psig (kPa).
   b. Pump shutoff pressure in feet of head or psig (kPa).
   c. Actual impeller size in inches (mm).
   d. Full-open flow rate in gpm (L/s).
   e. Full-open pressure in feet of head or psig (kPa).
   f. Final discharge pressure in feet of head or psig (kPa).
   g. Final suction pressure in feet of head or psig (kPa).
   h. Final total pressure in feet of head or psig (kPa).
   i. Final water flow rate in gpm (L/s).
   j. Voltage at each connection.
   k. Amperage for each phase.
R. Boiler Test Reports: For boilers, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.
   f. Fuel type and input in Btuh (kW).
   g. Number of passes.
   h. Ignition type.
   i. Burner-control types.
   j. Voltage at each connection.
   k. Amperage for each phase.

2. Test Data: Include design and actual values for the following:
   a. Operating pressure in psig (kPa).
   b. Operating temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Number of safety valves and sizes in NPS (DN).
   f. Safety valve settings in psig (kPa).
   g. High-limit setting in psig (kPa).
   h. Operating-control setting.
   i. High-fire set point.
   j. Low-fire set point.
   k. Voltage at each connection.
   l. Amperage for each phase.
   m. Draft fan voltage at each connection.
   n. Draft fan amperage for each phase.
   o. Manifold pressure in psig (kPa).

S. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.24 ADDITIONAL TESTS

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

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

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes pipe, duct, and equipment insulation.

1.2 DEFINITIONS
   A. Hot Surfaces: Normal operating temperatures of 100°F or higher.
   B. Cold Surfaces: Normal operating temperatures less than 75°F.
   C. Thermal Resistivity: “r-values” represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees (°F) between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.
   D. Density: Is expressed in lb/sq.ft.

1.3 SUBMITTALS
   A. Product data for each type of mechanical insulation identifying k-value, thickness, and accessories.
   B. Manufacturer’s installation instructions.
   C. Schedule of materials and thickness for each piece of equipment.

1.4 QUALITY ASSURANCE
   A. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E 84, by UL or other testing or inspecting organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.
      1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
      2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

1.5 SEQUENCING AND SCHEDULING
   A. Schedule insulation application after testing of piping and duct systems.

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 one of the following:

1. Glass Fiber:
   a. CertainTeed Corporation.
   b. Knauf Fiberglass GmbH.
   c. Manville.
   d. Owens-Corning Fiberglas Corporation.
   e. USG Interiors, Inc. - Thermafiber Division.

2. Flexible Elastomeric Cellular:
   a. Armstrong World Industries, Inc.
   b. Halstead Industrial Products.
   c. IMCOA.
   d. Rubatex Corporation.

3. Calcium Silicate:
   a. Manville.
   b. Owens-Corning Corporation.

4. Open Weave Glass Cloth Membrane:
   a. Perma Glas-Mesh Corp.

5. Vinyl-Acrylic Mastic:
   a. Childers Products Co.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.


C. Board: ASTM C 612, Class 2, semi-rigid jacketed board.

   1. Thermal Conductivity: 0.25 average maximum, at 75°F mean temperature.
   2. Density: 12 pcf average maximum.

D. Blanket: ASTM C 553, Type II, Class F-1, jacketed flexible blankets.

   1. Thermal Conductivity: 0.30 average maximum, at 75°F mean temperature.

E. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, jacketed.

   1. Thermal Conductivity: 0.27 average maximum at 75°F mean temperature.
   2. Density: 10 average maximum.

F. Adhesive: Produced under the UL Classification and Follow-up service.

   1. Type: Non-flammable, solvent-based.
   2. Service Temperature Range: Minus 20 to 180°F.

G. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.
2.3  FLEXIBLE ELASTOMERIC CELLULAR

A.  Material: Flexible expanded closed-cell structure with smooth skin on both sides.
   1.  Tubular Materials: ASTM C 534, Type I.
   2.  Sheet Materials: ASTM C 534, Type II.

B.  Thermal Conductivity: 0.27 average maximum at 75°F.

C.  Coating: Water based latex enamel coating recommended by insulation manufacturer.

2.4  CALCIUM SILICATE

A.  Material: ASTM C 533, Type I; inorganic, hydrous calcium silicate, non-asbestos fibrous reinforcement; incombustible.

B.  Form: Molded flat block, curved block, grooved block, and preformed pipe sections as appropriate for surface.

C.  Thermal Conductivity: 0.60 at 500°F.

D.  Dry Density: 15.0 pcf maximum.

E.  Compressive Strength: 60 psi minimum at 5 percent deformation.

F.  Fire Performance Characteristics: Provide materials identical to those whose fire performance characteristics have been determined, per test method indicated below, by UL or other testing and inspecting organization acceptable to authorities having jurisdiction.
   1.  Test Method: ASTM E 84.
   2.  Flame Spread: 0.
   3.  Smoke Developed: 0.

2.5  ADHESIVES

A.  Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer.

B.  Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:
   1.  Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
   2.  Class 2, Grade A for bonding glass fiber insulation to metal surfaces.

2.6  JACKETS

A.  General: ASTM C 921, Type 1, except as otherwise indicated.

1. Water Vapor Permeance: 0.02 perm maximum, when tested according to ASTM E 96.

2. Puncture Resistance: 50 beach units minimum, when tested according to ASTM D 781.

C. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 20-mils thick, roll stock ready for shop or field cutting and forming to indicated sizes.

1. Adhesive: As recommended by insulation manufacturer.

D. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultra-violet-resistant PVC.

1. Adhesive: As recommended by insulation manufacturer.

E. Aluminum Jacket: ASTM B 209, 3003 Alloy, H-14 temper, roll stock ready for shop or field cutting and forming to indicated sizes or factory cut and rolled to indicated sizes.

1. Finish and Thickness: Stucco embossed finish, 0.016 inch thick.
3. Elbows: Preformed 45-degree and 90-degree, short- and long-radius elbows, same material, finish, and thickness as jacket.

### 2.7 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Woven glass fiber fabrics, plain weave, presized a minimum of 8 ounces per sq. yd.

1. Tape Width: 4 inches.
2. Cloth Standard: MIL-C-20079H, Type I.
3. Tape Standard: MIL-C-20079H, Type II.

B. Bands: 3/4-inch wide, in one of the following materials compatible with jacket:

1. Stainless Steel: Type 304, 0.020 inch thick.
2. Galvanized Steel: 0.005 inch thick.
3. Aluminum: 0.007 inch thick.
4. Brass: 0.01 inch thick.
5. Nickel-Copper Alloy: 0.005 inch thick.

C. Wire: 14-gage nickel copper alloy, 16-gage, soft-annealed stainless steel, or 16-gage, soft-annealed galvanized steel.

D. Corner Angles: 28-gage, 1-inch by 1-inch aluminum, adhered to 2-inch by 2-inch kraft paper.

E. Anchor Pins: Capable of supporting 20 pounds each. Provide anchor pins and speed washers of sizes and diameters as recommended by the manufacturer for insulation type and thickness.
2.8 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.
   1. Water Vapor Permeance: 0.08 perm maximum.
   2. Temperature Range: Minus 20 to 180°F.

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.
   1. Water Vapor Permeance: 0.02 perm maximum.
   2. Temperature Range: Minus 50 to 250°F.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.

3.2 INSTALLATION, GENERAL

A. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each mechanical system.

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

C. Install vapor barriers on insulated pipes, ducts, and equipment having surface operating temperatures below 60°F.

D. Install insulation only after systems to be insulated have been tested and approved.

E. Apply insulation material, accessories, and finishes according to the manufacturer’s printed instructions.

F. Install insulation with smooth, straight, and even surfaces.

G. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

H. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

I. Seal Ends: Except for flexible elastomeric insulation, taper ends at 45 degree angle and seal with lagging adhesive. Cut ends of flexible elastomeric cellular insulation square and seal with adhesive.

J. Apply adhesives and coatings at manufacturer’s recommended coverage-per-gallon rate.

K. Keep insulation materials dry during application and finishing.

L. Install board and block materials with a minimum dimension of 12 inches and a maximum dimension of 48 inches.
M. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:

1. Metal ducts with duct liner.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
4. Flexible connectors for ducts and pipes.
5. Vibration control devices.
6. Testing laboratory labels and stamps.
7. Nameplates and data plates.
8. Access panels and doors in air distribution systems.
9. Return air ductwork concealed in spaces which are used as return air plenums need not be insulated, unless otherwise noted.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.
B. Stagger joints on double layers of insulation.
C. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.
D. Apply insulation with a minimum number of joints.
E. Apply insulation with integral jackets as follows:
   1. Pull jacket tight and smooth.
   2. Cover circumferential joints with butt strips, at least 3-inches wide, and of same material as insulation jacket. Secure with adhesive along both edges of butt strip and space 4 inches on center.
   3. Longitudinal Seams: Overlap seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
   4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints and at ends butt to flanges, unions, valves, and fittings.
   5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.
   6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere and seal. Extend patch at least 2 inches in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.
F. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

G. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer.

H. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer.

I. Floor Penetrations: Terminate insulation underside of floor assembly and at floor support at top of floor.

J. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight. Bond with adhesive.

1. Use same material and thickness as adjacent pipe insulation.

2. Overlap nesting insulation by 2 inches or 1-pipe diameter, which ever is greater.

3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.

4. Insulate elbows and tees smaller than 3-inches pipe size with premolded insulation.

5. Insulate elbows and tees 3 inches and larger with premolded insulation or insulation material segments. Use at least 3 segments for each elbow.

6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

K. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. For cold surface piping, extend insulation anchor legs a minimum of 12 inches and taper and seal insulation ends.

1. Inserts and Shields: Cover hanger inserts and shields with jacket material matching adjacent pipe insulation.

2. Special Treatment at Hanger Locations: At hanger locations on insulated piping 2” and larger, install high density rigid fiber glass pipe support blocks. On piping up to and including 5”, install one block at each hanger, directly on the bottom of the pipe. For 6”, 8”, and 10” piping, install two (2) blocks at each hanger oriented 30 degrees from each side of the bottom. For piping 12” and larger, orientate blocks at both the 30 degrees positions and directly on the bottom. Install blocks inside cut out section of pipe insulation, being careful not to damage the vapor barrier jacketing. Any jacketing so damaged should be repaired with matching vapor barrier tape.
3.4 GLASS FIBER PIPE INSULATION INSTALLATION

A. Bond insulation to pipe with lagging adhesive.
B. Seal exposed ends with lagging adhesive.
C. Seal seams and joints with vapor barrier compound.

3.5 FLEXIBLE ELASTOMERIC CELLULAR PIPE INSULATION INSTALLATION

A. Slip insulation on the pipe before making connections wherever possible. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.

B. Valves, Fittings, and Flanges: Cut insulation segments from pipe or sheet insulation. Bond to valve, fitting, and flange and seal joints with adhesive.

1. Miter cut materials to cover soldered elbows and tees.

3.6 CALCIUM SILICATE PIPE INSULATION INSTALLATION

A. Secure insulation with stainless-steel bands spaced at 12-inch intervals.
B. Apply 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 16-gage soft-annealed stainless-steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
C. Finishing: Apply a skim coat of mineral fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on 1 layer of glass cloth or glass tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth finish.
D. Metal Jacket: Where indicated, apply metal jacket over finished insulation as specified in this Section for installation of metal jackets.

3.7 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Groove and score insulation materials as required to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

B. Insulation Thicknesses Greater than 2 Inches: Install insulation in multiple layers with staggered joints.

C. Bevel insulation edges for cylindrical surfaces for tight joint.

D. Secure sections of insulation in place with wire or bands spaced at 9-inch centers, except for flexible elastomeric cellular insulation.

E. Protect exposed corners with corner angles under wires and bands.

F. Manholes, Handholes, and Information Plates: Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
G. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

H. Pumps: Where insulation is indicated, fabricate galvanized steel boxes lined with insulation. Fit boxes around pumps and coincide joints in box with the splits in the pump casings. Fabricate joints with outward bolted flanges.

3.8 GLASS FIBER EQUIPMENT INSULATION INSTALLATION

A. Secure insulation with anchor pins and speed washers.

B. Space anchors at maximum intervals of 18 inches in both directions and not more than 3 inches from edges and joints.

C. Apply a smoothing coat of insulating and finishing cement to finished insulation.

3.9 FLEXIBLE ELASTOMERIC CELLULAR EQUIPMENT INSULATION INSTALLATION

A. Install sheets of the largest manageable size.

B. Apply full coverage of adhesive to the surfaces of the equipment and to the insulation.

C. Butt insulation joints firmly together and apply adhesive to insulation edges at joints.

3.10 DUCT INSULATION

A. Install block and board insulation as follows:

1. Adhesive and Band Attachment: Secure block and board insulation tight and smooth with at least 50 percent coverage of adhesive. Install bands spaced 12 inches apart. Protect insulation under bands and at exterior corners with metal corner angles. Fill joints, seams, and chipped edges with vapor barrier compound.

2. Speed Washers Attachment: Secure insulation tight and smooth with speed washers and welded pins. Space anchor pins 18 inches apart each way and 3 inches from insulation joints. Apply vapor barrier coating compound to insulation in contact, open joints, breaks, punctures, and voids in insulation.

B. Blanket Insulation: Install tight and smooth. Secure to ducts having long sides or diameters as follows:

1. Smaller Than 24 Inches: Bonding adhesive applied in 6-inch-wide transverse strips on 12-inch centers.

2. 24 Inches and Larger: Anchor pins spaced 12 inches apart each way. Apply bonding adhesive to prevent sagging of the insulation.

3. Overlap joints 3 inches.

4. Seal joints, breaks, and punctures with vapor barrier compound.

5. Minimize compression during installation.
3.11 JAYETS

A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 1-1/2-inch laps at longitudinal joints and 3-inch-wide butt strips at end joints.

1. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.

2. Provide PVC fitting covers.

B. Interior Exposed Insulation in Mechanical Rooms: Install continuous PVC jackets.

C. Exterior Exposed Insulation: Install continuous aluminum jackets and seal all joints and seams with waterproof sealant.

D. Install metal jacket with 2-inch overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 12 inches on center and at butt joints.

E. Install the PVC jacket with 1-inch overlap at longitudinal and butt joints and seal with adhesive.

F. Special Protection for Ductwork Exposed to the Weather:

1. Rectangular: Weatherproof with a durable asbestos-free water based vinyl-acrylic mastic, applied in two (2) coats. Apply the first tack coat at a rate of two (2) gallons per 100 sq. ft. While still wet, lay an open weave glass cloth membrane and embed with all fabric seams overlapped 2” minimum. Apply a finish coat at a coverage of four (4) gallons per 100 sq. ft., fully covering the cloth membrane, so that the minimum dry film thickness is 1/16”. Trowel, spray, or wet brush to a smooth, even finish. Install the insulation on the top of the ductwork with a positive pitch to drain off all water and prevent ponding on the top surfaces.

2. Round: Weatherproof with a high impact, UV resistant polyvinyl chloride jacketing, 20 mil. thickness minimum. Cut to the proper size from roll stock, including a 3” – 4” overlap for both longitudinal and circumferential joints. Install over duct insulation, avoiding “fishmouths,” and secure longitudinal overlap with either outward clinching staples or stainless steel tack fasteners. Tape all joints with matching PVC tape. Position all longitudinal overlaps at either the 4:30 or 7:30 position to shed water. Secure jacketing with aluminum banding on 24” centers.

3. Weatherproof outdoor ductwork ONLY when the outdoor temperature is 40°F or greater.

3.12 FINISHES

A. Flexible Elastomeric Cellular Insulation: After adhesive has fully cured, apply 2 coats of protective coating to exposed insulation.

3.13 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules at the end of this Section.

B. Interior Piping Systems: Unless otherwise indicated, insulate the following piping systems:

1. Refrigerant.
2. Condensate.
3. Cooling coil condensate.

C. Exterior Piping Systems: Unless otherwise indicated, insulate the following piping systems:
   1. Refrigerant.

D. Duct Systems: Unless otherwise indicated, insulate the following duct systems:
   1. Interior supply, return and outside air ductwork.
   2. Exterior exposed supply and return ductwork.
   3. Interior exposed and concealed supply fans, air handling unit casings and outside air plenums.

3.14 PIPE INSULATION SCHEDULES

A. General: Abbreviations used in the following schedules include:

B. Cooling Coil Condensate: 1/2-inch-thick glass fiber insulation with vapor barrier. Field-applied jacket is not required.

### INTERIOR REFRIGERANT

<table>
<thead>
<tr>
<th>Pipe Sizes (NPS)</th>
<th>Materials</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 or less</td>
<td>Glass Fiber</td>
<td>1</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>2 or greater</td>
<td>Glass Fiber</td>
<td>1-1/2</td>
<td>Yes</td>
<td>None</td>
</tr>
</tbody>
</table>

### EXTERIOR REFRIGERANT

<table>
<thead>
<tr>
<th>Pipe Sizes (NPS)</th>
<th>Materials</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 or less</td>
<td>Glass Fiber</td>
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<td>Yes</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Flexible Elastomeric</td>
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<td>Yes</td>
<td>A</td>
</tr>
<tr>
<td>2 or greater</td>
<td>Glass Fiber</td>
<td>1-1/2</td>
<td>Yes</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Flexible Elastomeric</td>
<td>1-1/2</td>
<td>Yes</td>
<td>A</td>
</tr>
</tbody>
</table>
3.15 DUCT SYSTEMS INSULATION SCHEDULE

A. General: Abbreviations used in the following schedules include:


### INTERIOR CONCEALED HVAC SUPPLY, RETURN AND OUTSIDE AIR DUCTS AND PLENUMS

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber</td>
<td>Blanket</td>
<td>1-1/2</td>
<td>Yes</td>
<td>None</td>
</tr>
</tbody>
</table>

### INTERIOR EXPOSED HVAC SUPPLY, RETURN AND OUTSIDE AIR DUCTS AND PLENUMS

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber</td>
<td>Board - Rect.</td>
<td>1-1/2</td>
<td>Yes</td>
<td>None</td>
</tr>
</tbody>
</table>

### EXTERIOR EXPOSED HVAC SUPPLY AND RETURN DUCTS AND PLENUMS

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber</td>
<td>Board - Rect.</td>
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<tr>
<td>Glass Fiber</td>
<td>Pipe - Round</td>
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<td>Yes</td>
<td>A</td>
</tr>
<tr>
<td>Flexible Elastomeric</td>
<td>Sheet</td>
<td>2-1/2</td>
<td>Yes</td>
<td>A</td>
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### INTERIOR EXPOSED HVAC SUPPLY FANS, AIR HANDLING UNITS, CASINGS, AND PLENUMS

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber</td>
<td>Board</td>
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<td>None</td>
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</table>

### INTERIOR EXPOSED RANGE HOOD EXHAUST DUCTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Silicate</td>
<td>Board</td>
<td>As Req’d for 1-Hr Rating</td>
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<td>(SS)</td>
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</table>
### INTERIOR CONCEALED RANGE HOOD EXHAUST DUCTS

<table>
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<tr>
<th>Material</th>
<th>Form</th>
<th>Thickness in Inches</th>
<th>Vapor Barrier Required</th>
<th>Field-Applied Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Silicate</td>
<td>Board</td>
<td>As Req’d for 1-Hr Rating</td>
<td>No</td>
<td>None</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 230900 INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units that are not supplied with factory-wired controls.

1.2 SYSTEM DESCRIPTION

A. Provide a microprocessor based direct digital control (DDC) building automation system (BAS) as a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown. Communication between facility-wide BAS workstations, servers and laptops shall utilize BACnet protocol and be configured for operations, and connected by common fiber optic system or other approved network connection serving building. The system shall include software with all necessary means for global data exchange, scheduling, local and remote control and adjustment; load shedding for demand controls; event management; monitoring; trending; logging; maintenance notification; and alarms. The existing facility EMCS shall be replaced in its entirety.

B. Building automation system main panels for this project shall be located in Room XXX. Coordinate the final location with the facility.

C. All utility meters including existing domestic water meter, natural gas meter, and electric meter shall have remote meter readings through the BAS. Utility meters shall be provided by the utility companies.

D. The control system shall be complete in all respects with system completeness (turnkey system) for the building automation system (BAS). System shall be a BACnet direct digital control system. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a secure web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface. Input/output interface labeling and naming conventions shall be descriptive, and shall reflect equipment and actual intended function (i.e., CHWP-1 S/S vs. IO-1). Equipment tags and labels used in the construction documents shall be maintained. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, wiring, and accessories connected to controllers to operate mechanical systems according to sequences of operation indicated or specified. Provide all hardware, software and ancillary components, and wiring not specifically indicated or specified, but necessary to make the system function according to the intent of the specification. The control system contractor shall also be responsible for the proper operation of the control system and shall provide all necessary debugging and calibration. Size all control apparatus to properly supply and/or operate and control the apparatus served. Note that the control specifications in the design documents may be generic or have a limited amount interfacing information or job specifics (to varying degrees). Examine not only the plans and specifications for this Specification Section, but plans and specifications of other related sections and visit the site to become acquainted with all project conditions including existing conditions. Execution of Contract is evidence that control system contractor has examined all drawings and specifications, and that all conditions of installing the work in this Section are verified. Later claims for labor and materials required due to difficulties encountered, which could have been foreseen had examination been made, will not be recognized. The control system shall fully integrate all distributed digital controls, energy management controls and interfaces to mechanical equipment.
specified elsewhere in Division 23. The DDC panels shall be located in new electric room on the second floor as indicated on the drawing. The new BACnet DDC system shall have been totally programmed and verified as satisfying the requirements of the Sequence of Operation contained hereinafter. However, it shall be possible to reprogram the panels on site either by the BAS Contractor or the Owner. The new DDC system shall be configured to perform all control, alarming, scheduling and energy management routines either as a distributed processing unit to a central remote monitoring and control system or as a stand alone unit. The DDC system shall have capability to allow for remote monitoring, controls and reprogramming by system operators through the existing BAS systems. Additional capabilities shall include all physical points be automatically trended and alarmed, gathering reports and logs, programming and downloading databases.

E. BAS contractor shall follow all Owner network configuration protocols and requirements for security and accessibility. BAS shall not be accessible via the internet; coordinate details and requirements directly with Owner’s IT group.

F. Upon completion of project ALL host software, documentation, databases, application programming tools, graphical creation tools, passwords shall become owner’s property

1.3 SUBMITTALS

A. Product Data for each type of product specified. Include manufacturer’s technical Product Data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions.

B. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Submit damper leakage and flow characteristics, plus size schedule for controlled dampers.

C. Shop Drawings containing the following information for each control system:

1. Schematic flow diagram showing fans, pumps, coils, dampers, valves, and control devices.
2. Each control device labeled with setting or adjustable range of control.
3. Diagrams for all required electrical wiring, with point-to-point labels. Clearly differentiate between factory-installed and field-installed wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
7. Listing of connected data points, including connected control unit and input device.
8. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
9. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
10. Software description and sequence of operation.
D. Wiring diagrams detailing wiring for power, signal, and control systems with point-to-point labels and differentiating clearly between manufacturer-installed and field-installed wiring.

E. Maintenance data for control systems equipment to be included in the operation and maintenance manual. Include the following:

1. Maintenance instructions and spare parts lists for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

F. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer specializing in control system installations.

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing control systems similar to those indicated for this Project and that have a record of successful in-service performance.

C. Startup Personnel Qualifications: Engage specially trained personnel in direct employ of manufacturer of primary temperature control system.

D. Comply with NFPA 90A.

E. Comply with NFPA 70.

F. Coordinate equipment selection with Division 26 to achieve compatibility with equipment that interfaces with that system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

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:

1. Direct Digital Control (DDC) Systems and Components:
2.2 DIRECT DIGITAL CONTROL (DDC) EQUIPMENT

A. Application Software: Include the following:
   1. Input/output capability from operator station.
   2. Operator system access levels via software password.
   3. Database creation and support.
   4. Dynamic color graphic displays.
   5. Alarm processing.
   7. Automatic restart of field equipment on restoration of power.
   8. Data collection.
   9. Graphic development on workstation.
   10. Maintenance management.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and back-up power source.
   1. Units monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse input/output.
      c. Monitoring, controlling, or addressing data points.
      d. Testing and developing control algorithms without disrupting field hardware and controlled environment.

C. Local Area Networks (LANs): Not less than 60 stations or nodes at minimum 19.2 kB.
   1. System Support: Capacity for a minimum of 10 workstations connected to multiuser, multitasking environment with concurrent capability to access DDC network or control units.

D. Software: Update to latest version of software at project completion. Include and implement the following capabilities from the control units:
   1. Units of Measure: Inch-pound and SI metric.
   2. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, DDC with fine tuning, and trend logging.
3. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
4. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
5. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet. LON is not an acceptable protocol.

B. The Building Automation System (BAS) shall consist of a two-tiered system of an upper level Ethernet TCP/IP Network, and a twisted-pair field bus of Standalone Digital Control Units (SDCUs). All field bus communications must be routed through Ethernet based network controllers or routers, and not directly through PC workstations or servers.

C. BAS contractor shall follow all Owner network configuration protocols and requirements for security and accessibility. BAS shall not be accessible via the internet; coordinate details and requirements directly with Owner’s IT group. Remote internet or VPN access shall not be incorporated into the system; any configuration, diagnostics and services by the BAS supplier shall be done at the DPU facility with a direct, secure login.

D. Level 1 Controllers, the main backbone of the system, shall be an Ethernet 10/100bT LAN/WAN. Network Router/Controllers, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices.

E. Where required, provide a BACnet gateway to interface to non-BACnet systems that use the Modbus RTU protocol or other proprietary protocol. The gateway shall communicate directly over Ethernet TCP/IP and shall use the BACnet/IP protocol to communicate with the operators workstation.

F. Level 2 Controllers of the system shall consist of one MS/TP field buses managed by the Network Router/Controllers. Minimum speed shall be 76.8kbps. The Level 2 field bus consists of an RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs).

2.4 CONTROL PANELS

A. Central (Master) Control Panels: Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.

B. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer’s standard shop-painted finish and color.

3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.

4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

C. STANDALONE DIGITAL CONTROL UNITS (SDCU)

1. Standalone Digital Control Units shall provide control of HVAC, including air handling units, rooftop units, variable air volume boxes, and other mechanical equipment. Each controller shall be fully programmable, contain its own control programs and will continue to operate in the event of a failure or communication loss to its associated network controller.

2. Both the operating system of the controller, plus the application program for the controller, shall be stored in non-volatile, FLASH memory. Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

3. SDCUs shall have a RS-485 communication port to the MS/TP field bus, operating at a speed of at least 76.8kbps.
   a. Input/Output: Each SDCU shall have enough inputs and outputs to meet the application’s required points. Each SDCU shall support universal inputs, whereas any input may be software-defined as:
      1.) Digital Inputs for status/alarm contacts.
      2.) Counter Inputs for summing pulses from meters.
      3.) Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
      4.) Analog inputs for pressure, humidity, flow and position measurements.
   b. SDCU’s must support both digital and analog output types:
      1.) Digital Outputs for on/off equipment control.
      2.) Analog Outputs for valve and damper position control, and capacity control of primary equipment.

4. Expandability:

5. For larger controllers (16 base inputs and up), provide input and output expansion through the use of plug-in modules. At least two I/O modules must be capable of being added to the base SDCU.

6. Hardware Override Switches:
   a. All digital outputs on air handling unit controllers shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output on air handling unit controllers shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

7. Room Sensor Support: The SDCU shall support the following two types of room sensors:
   a. Type A: Room thermistor in a stainless steel cover plate with vandal proof screws
   b. Type B: Room thermistor with plastic cover plate and LCD display of space temperature.
2.5 ANALOG CONTROLLERS

A. Step Controllers: 6-stage or 10-stage type, with heavy-duty switching rated to handle loads, UL listed and operated by electric motor.

B. Electric Outdoor Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range -10 to 70°F (-12 to 21°C), and single- or, double-pole contacts.

C. Electronic Controllers: Wheatstone bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

2.6 TIME CLOCKS

A. Seven-day, programming-switch timer with synchronous-timing motor and 7-day dial; continuously charged, nickel-cadmium-battery-driven, 8-hour, power-failure carryover; multiple-switch trippers; minimum of 2 and maximum of 8 signals per day with 2 normally open and 2 normally closed output contacts.

B. Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual ON-OFF-AUTO switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.

2.7 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant, for wall, immersion, or duct mounting as required.

   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Insertion Elements in Ducts: Use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).
   d. Averaging Elements in Ducts: Use where ducts are larger than 9 sq. ft. (1 sq. m) or where prone to stratification, length as required.
   e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
   f. Room Sensors: Match room thermostats, locking cover.
   g. Outside Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

   a. Accuracy: 5 percent full range with linear output.
   b. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0 to 0.25 inch wg (0 to 62 Pa).
d. Duct Static-Pressure Range: 0 to 5 inches wg (0 to 1243 Pa).

4. Pressure Transmitters: Direct acting for gas, liquid, or steam service, range suitable for system, proportional output 4 to 20 mA.

5. Carbon Monoxide Detector: UL listed carbon monoxide detector suitable over temperature range of 40 to 100°F, powered with 120 VAC/1 PHASE/60 HZ, and calibrated to alarm at 25 ppm. The detector shall have audible locale alarm horn and shall be remotely monitored by the BAS system. Sensor shall be wall mounted and loop powered from DDC control panel. Coordinate sensor signal type (4-20 ma or 0-10vdc) based on DDC system requirements. Sensor shall be Veris Industries, Model G-Series or approved equal.

6. Carbon Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over temperature range of 23 to 130°F (-5 to 55°C), calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, duct mounted, or wall mounted.

7. Occupancy Sensor - Ceiling Mounted  
a. Temperature and Humidity resistant ceiling mount application, with omni-directional ultrasonic detection or passive infrared detection, 1,000 square feet coverage. Light level sensor is not required. Solid state circuitry, volumetric coverage, with coverage pattern adjustable by lens selection. Detection shall be maintained when a person of average size moves at least 12 inches at an approximate speed of 12 inches per second.

b. Coverage: Minimum of 900 square feet, when mounted at 9 feet.

c. Time Delay: “Off” delay adjustable 15 seconds to 15 minutes.

d. Mounting Provisions: Manufacturers standard, and/or field fabricated, as required.

e. Relay Modules: Separately mounted U.L. listed power supply consisting of transformer and contact closure relay. Power output of transformer to be 100 ma at 24 volts DC, capable of operating one or two sensors. Transformer primary voltage to be 120 or 277 volts AC as indicated or required.

f. Relay Control Boxes: NEMA-1 steel enclosures, sized as required to house the indicated relay module. Boxes to include steel barrier for mounting all relay, and segregating line voltage and control voltage wiring. Include engraved nameplate “Occupancy Sensor Control Box”. Coordinate relay for sensor and connected equipment voltages and current requirements.

g. Power Pack: Provide manufacturer's recommended power pack for sensor provided.

h. Acceptable Manufacturers: The Watt Stopper

1.) Sensor: #DT-300 Series.

B. Equipment Operation Sensors: As follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg (0 to 1243 Pa).

2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psi (55 to 414 kPa).


C. Valve/Damper Position Indication: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

D. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with
appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.

2.8 THERMOSTATS

A. Line-Voltage, ON-OFF Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual ON-OFF-AUTO selector switch; UL listed for electrical rating.

1. Equip thermostats, which control electric heating loads directly, with OFF position on dial wired to break ungrounded conductors.

2. Dead Band: Maximum 2°F (1°C).

B. Low-Voltage Modulating Thermostats: Potentiometer, operated by vapor-filled bellows.

C. Remote-Bulb Thermostats: ON-OFF or modulating type, liquid-filled to compensate for changes in ambient temperature, with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.

2. Bulbs in air ducts with flanges and shields.

3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit, adequately supported.

4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.

5. ON-OFF, remote-bulb thermostats with precision snap switches, with electrical ratings required by application.

6. Construct modulating, remote-bulb, potentiometer thermostats so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

D. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75°F (24°C) above normal maximum operating temperature, with the following:


2. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

E. Room Thermostat Construction: Manufacturer’s standard locking covers.

1. Thermometer: Red-reading glass or spiral bimetal.

2. Guards: Heavy-duty, clear plastic or metal-wire, tamperproof guards.

3. Locking Covers: With only temperature indication visible.

4. Limits: Provide on heating/cooling dual-temperature thermostats, to prevent setting cooling set point below 75°F (24°C), and heating set point above 75°F (24°C).
F. Room Thermostat Accessories: As follows:
   1. Insulating Bases: For thermostats located on exterior walls.
   2. Thermostat Guards: Locking transparent-plastic mounted on separate base.
   3. Adjusting Key: As required for device.

G. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

H. Airstream Thermostats: 2-pipe, fully proportional, single temperature, with adjustable set point in middle of range and adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

I. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psi (172 kPa), cast housing with position indicator and adjusting knob.

2.9 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or 2-position action.

   1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

   2. Spring-Return Motors for Valves Larger Than 2-1/2 Inches (64 mm): Size for running and breakaway torque of 150 inch-pounds (16.9 N x m).

   3. Nonspring-Return Motors for Dampers Larger Than 25 sq. ft. (2.3 sq. m): Size for running torque of 150 inch-pounds (16.9 N x m) and breakaway torque of 300 inch-pounds (33.9 N x m).

B. Electronic Operators: Select operator for full shutoff at maximum pump differential pressure.

2.10 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class indicated. Where type or body material is not indicated, make selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system.

B. Globe Pattern: As follows:

   1. Up to 2 inches (DN 50): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

   2. Over 2 inches (DN 50): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.

   3. Hydronic Systems: As follows:
      a. Rating: Service at 125 psi WSP (862 kPa) and 250 °F (121 °C).
      b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
1.) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

c. Sizing: 3-psi (21-kPa) maximum pressure drop at design flow rate.

d. Flow Characteristics: 2-way valves have equal percentage characteristics; 3-way valves have linear characteristics. Select operators to close valves against pump shutoff head.

C. Butterfly Pattern: Iron body; bronze, aluminum-bronze, or stainless-steel disc; resilient, replaceable seat for service to 180°F (82°C) wafer or lug ends; extended neck.

1. Rating: Service at 125 psi WSP (862 kPa) and 250°F (121 °C).

2. Sizing: 1-psi (7-kPa) maximum pressure drop at design flow rate.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.

3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

E. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

DAMPERS

A. Dampers: Low-leakage, AMCA-rated, parallel or opposed blade design; form frames from not less than 0.1084-inch (2.8-mm) galvanized steel with mounting holes for duct mounting; damper blades not less than 0.0635-inch (1.6-mm) galvanized steel, with maximum blade width of 8 inches (203 mm).

1. Blades secured to 1/2-inch (13-mm) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass. Ends sealed against spring-stainless-steel blade bearings. Thrust bearings at each end of every blade.

2. Operating Temperature Range: From -40 to 200°F (-40 to 93°C).

3. For standard applications as indicated, (as selected by manufacturer’s sizing techniques) with optional closed-cell neoprene edging.

4. For low-leakage applications as indicated, provide parallel or opposed blade design (as selected by manufacturer’s sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. (51 L/s/sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when damper is being held by torque of 50 inch-pounds (5.6 N x m); test in accordance with AMCA 500.

RELAYS

A. Relays: Electrically operated, mechanically held with heavy duty industrial grade construction. Provide with number of poles and contacts of type required for application where relay is being used. Coordinate relay for required voltages between equipment, devices, control system, etc.
2.13 CONTROL CABLE

A. Electronic Cable for Control Wiring: Provide all control wiring for the complete DEC Control System. Refer to Division 26 for control wiring materials.

2.14 OPERATOR INTERFACE

A. Operator Interface. The workstation server shall reside on secure high-speed network with the building controllers. The server shall be configured to communicate in a secure and encrypted manner any alarms or notifications to the Owners in-house email servers. The communication shall be outgoing (one-way) only, and configuration details shall be coordinated with Owner’s IT personnel. The workstation shall provide the following capabilities and functionality at a minimum through its interface:

1. An operator authentication system that requires an operator to log in before viewing or editing any data, and which can be configured to limit the privileges of an individual operator.

2. The ability to view and acknowledge any alarm in the system. Alarms or links to alarms shall be provided on a contiguous list so the operator can quickly view all alarms.

3. Depict each mechanical system and building floor plan by a point-and-click graphic. Pertinent setpoints, reading and alarm indications shall be indicated on that graphic and shall be adjustable based on security permissions a user is allowed.

4. A summary page or pages for each piece of equipment in the system. This page shall include the current values of all critical I/O points and shall allow the operator to lock binary points on or off and to lock analog points to any value within their range.

5. Navigation links that allow the operator to quickly navigate from the home screen to any piece of equipment in the system, and then return to the home screen. These links may be arranged in a hierarchical fashion, such as navigating from the home screen to a particular building, then to a specific floor in the building, and then to a specific room or piece of equipment.

6. Input/output interface labeling and naming conventions that are descriptive, and that reflect equipment and actual intended function (i.e., CHWP-1 S/S vs. IO-1). Equipment tags and labels used in the construction documents shall be maintained

B. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet Annex J.

1. The system shall not have any web access per Owner system security requirements.

C. Workstation. The workstations and servers shall meet or exceed DDC system manufacturer's recommended specifications. The system shall have sufficient memory to store system software, one year of data for trended points as required at system acceptance. Configure workstations and network
connections to meet specified memory and performance. Serial, parallel, and network communication ports and cables required for proper system operation.

D. The operators workstation shall consist of the following:

1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times. Hard disk shall have sufficient memory to store system software, one year of data for trended points, and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Workstations shall be IBM-compatible PCs with a minimum of: the following:
   a. Intel latest generation processor
   b. 8 GB RAM
   c. 500 GB hard disk providing data at 100 MB/sec
   d. 24x CD-RW/DVD drive
   e. 32” LED display
   f. 3 3.0 USB ports and network communication port.

E. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.

2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.

3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.

4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.

5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.

6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.

7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.

8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and
of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately. System shall be configured with differing levels of access and functionality for each individual operator.

F. System Software.

1. Operating System. Operating system shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Vista, Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris.

2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
   a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
   b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
   c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
   d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins selected to meet Owner system security requirements.

G. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

3. System Configuration. Operators shall be able to configure the system.

4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.

5. Security. System shall require a user name and password to view, edit, add, or delete data.
   a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.
   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.

6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 230993 Sequence of Operations for HVAC Controls or shown on the drawings. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.

9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.

11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Section 230993 Sequence of Operations for HVAC Controls. Trends shall be BACnet trend objects.

12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.

13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

14. Standard Reports. Furnish the following standard system reports:
   a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
   c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
      1.) Alarm History.
      2.) Trend Data. Operator shall be able to select trends to be logged.
      3.) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.
15. Environmental Index. System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from the heating or cooling setpoint. If humidity is being measured within the zone then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels. Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trend logs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.

17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

18. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

   a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.

   b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

   c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

   d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

   e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

   f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

1. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

2. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

H. Portable Operator’s Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator’s Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

I. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2004, BACnet Annex J.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation. Verify that field end devices, wiring, and pneumatic tubing are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment as indicated to comply with manufacturer’s written instructions.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve the sequence of operation specified.

D. Verify location of thermostats, humidity sensors, and other exposed control sensors with plans and room details before installation. Locate 48 inches (1524 mm) above floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Provide temperature sensors of type and location as indicated below:

1. Type A Sensor (Stainless Steel Cover Plate):
   a. Entrances.
   b. Public areas.
   c. Locker rooms/Shower rooms.
   d. Fitness Center/Strength Training.
   e. Storage Rooms.
   f. Classrooms.
   g. Shops.
   h. Warehouses.
2. Type B Sensor (Plastic Cover Plate with LCD Temperature Display):
   a. Offices.
   b. Conference Rooms.

F. Each temperature sensors shall be field calibrated to within 1°F of the control system set-point after installation.

G. Install damper motors on outside of duct in warm areas, not where exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Division 23 Sections specifying mechanical identification.

I. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section “Hydronic Piping.”

J. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.3 ELECTRICAL WIRING AND CONNECTIONS

A. Install raceways, boxes, and cabinets according to Division 26.

B. Install building wire and cable according to Division 26.

C. Install signal and communication cable according to Division 26 Section.
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where a number of cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, neatly along hinge side; protect against abrasion. Tie and support conductors neatly.
   6. Number-code or color-code conductors, except local individual room controls, for future identification and servicing of control system.
   7. Signal and communication cable shall not be routed in raceway with power wire and cable.

D. Connect electrical components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer’s published torque-tightening values for equipment connectors. Where manufacturer’s torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

E. Connect manual reset limit controls independent of manual control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect HAND-OFF-AUTO selector switches to override automatic interlock controls when switch is in HAND position.
3.4 COMMISSIONING

A. Manufacturer’s Field Services: Provide the services of a factory-authorized service representative to start control systems.

B. Test and adjust controls and safeties.

C. Replace damaged or malfunctioning controls and equipment.

D. Start, test, and adjust control systems.

E. Demonstrate compliance with requirements.

F. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.5 DEMONSTRATION

A. Manufacturer’s Field Services: Provide the services of a factory-authorized service representative to demonstrate and train Owner’s maintenance personnel as specified below.

1. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Schedule training with Owner with at least 7 days’ notice.

3. Provide the following operator training at a minimum:

   a. Four – 8 hour sessions totaling 32 hours in building automation training. Training shall be broken up into the following sessions:

      1.) Two – 8 hour sessions at system start.

      2.) One – 8 hour sessions during the warranty period – exact time and date to be determined by the Owner.

      3.) One – 8 hour session at the end of the warranty period.

   b. Training shall include a complete review of

      1.) Data displayed.

      2.) Alarm and status descriptors.

      3.) Requesting data.

      4.) Execution of commands.

      5.) Request of logs and development of trends.

      6.) Trouble shooting technics.

END OF SECTION
SECTION 230951 - MOTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

1.2 SUBMITTALS

A. Product Data: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lug; and coatings.

B. Factory Test Reports: For specified tests.

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

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Listing and Labeling: Provide motors specified in this Section that are listed and labeled.

1. Terms “Listed and Labeled”: As defined in the National Electrical Code, Article 100.


3. Motors shall be UL labeled.
   a. Motors shall conform to NEMA Standards MGI, Motors and Generators.

PART 2 - PRODUCTS

2.1 BASIC MOTOR REQUIREMENTS

A. Basic requirements apply to mechanical equipment motors, unless otherwise indicated.

B. Motors 1/2 HP and Larger: Polyphase.

C. Motors Smaller than 1/2 HP: Single phase.

D. Frequency Rating: 60 Hz.

E. Voltage Rating: Determined by voltage of circuit to which motor is connected.

F. Service Factor: According to NEMA MG 1, unless otherwise indicated.

G. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof, unless otherwise indicated.
2.2 POLYPHASE MOTORS

A. Description: NEMA MG 1, medium induction motor.
   1. Design Characteristics: NEMA MG 1, Design B, unless otherwise indicated.
   3. Stator: Copper windings, unless otherwise indicated. Multispeed motors have separate winding for each speed.
   4. Rotor: Squirrel cage, unless otherwise indicated.
   5. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
   6. Temperature Rise: Match insulation rating, unless otherwise indicated.
   7. Insulation: Class F, unless otherwise indicated.

B. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for indicated controller, with required motor leads brought to motor terminal box to suit control method.

C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Inverter duty rated.
   2. Critical vibration frequencies are not within operating range of controller output.
   3. Temperature Rise: Match rating for Class B insulation.
   4. Insulation: Class H.
   5. Thermal Protection: Where indicated, conform to NEMA MG 1 requirements for thermally protected motors.

D. Rugged-Duty Motors: Where indicated, motors are totally enclosed with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings are insulated with nonhygroscopic material. External finish is chemical-resistant paint over corrosion-resistant primer.

E. Source Quality Control: Perform the following routine tests according to NEMA MG 1:
   1. Measurement of winding resistance.
   2. No-load readings of current and speed at rated voltage and frequency.
   3. Locked rotor current at rated frequency.
   4. High-potential test.
   5. Alignment.
2.3 SINGLE-PHASE MOTORS

A. Type: As indicated or selected by manufacturer from one of the following, to suit starting torque and other requirements of specific motor application.

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: Do not use, unless motors are smaller than 1/20 hp.

C. Thermal Protection: Where indicated or required, internal protection automatically opens power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal protection device automatically resets when motor temperature returns to normal range, unless otherwise indicated.

D. Bearings: Ball-bearing type for belt-connected motors and other motors with high radial forces on motor shaft. Sealed, prelubricated sleeve bearings for other single-phase motors.

PART 3 - EXECUTION

3.1 ADJUSTING

A. Use adjustable motor mounting bases for belt-driven motors.

B. Align pulleys and install belts.

C. Tension according to manufacturer’s written instructions.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.

B. The sequences of operation are provided to assist in the familiarization with the control logic presented on the system schematics. The sequences are not intended to be all inclusive.

It is understood that upon a control loop set point being satisfied, equipment shutdown or equipment failure, the reverse sequence from what is described shall occur to shutdown systems or stop equipment in a controlled manner.

Some of the simpler, repetitive logic necessary has not been included in the sequences.

The control system sequence of operation shall be developed with the input, and final approval, of the Owner.

C. Operating equipment, devices, and system components required for control systems are specified in other sections.

1.2 SUBMITTALS

A. Refer to Section 230900 for submittal requirements.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL

A. Setpoints and schedules described herein shall be adjustable by the owner. Coordinate the various levels of security/access with Owner.

B. Provide wall mount space temperature sensor with temperature indication.

1. Provide wire mesh guard over space temperature sensors in shop and warehouse areas.

C. Upon a signal from the fire alarm system or a fire alarm control panel, HVAC air handling equipment shall be shut down and outside air control dampers shall close, with the exception of hazardous exhaust systems. The controls contractor shall provide wiring, conduit and all necessary devices from the fire control panel to the Building Automation System (BAS). When the fire alarm has cleared, each unit shall revert to its scheduled operating mode.

D. Provide data jacks for BAS laptop access in control cabinets of all AHUs, Chillers and Boiler room.

E. All heating control valves shall be Normally Open.

F. During electrical power outages, the boilers, boiler pumps and both heating distribution pumps shall be powered from an emergency power generator. Provide all required control wiring and devices
powered from emergency generator circuits to maintain operation of the heating equipment during heating season blackouts. Provide separate outside air temperature sensor if required. Provide means of avoiding initiation of power outage sequence when the generator is under test or service runs.

G. The outdoor air quantity for all air handling units shall be monitored, and an alarm shall be generated whenever the outside air quantity drops more than 10% below the minimum ventilation quantity for each respective unit.

H. Provide starters/contactors/relays required for the control of HVAC equipment that are not provided by equipment manufacturers or electrical contractor.

3.2 CHILLED WATER SYSTEM (CH-1, CH-2, BT-1,2,3, CHWP-1,2, CHWP-3,4, HX-1, HRP-1,2)

A. General: The chilled water system shall consist of the following:
1. Two natural gas engine driven chillers (CH-1, CH-1).
2. Chillers piped in parallel with CHW buffer volume (BT-1, BT-2, BT-3).
3. Primary chilled water pumps – variable flow (CHWP-1, CHWP-2).
5. Chiller NG engine waste heat recovery shell and tube heat exchanger (HX-1).
6. Heat recovery pumps (chiller side and boilers side) - constant speed (HRP-1, HRP-2).

B. Chilled Water System Control Interface:
1. The cooling chilled water system shall be operated during the cooling season only. The equipment shall be winterized and shut down during the heating season. Schedules for chilled water system operation and shut down shall be provided by the Owner.
2. General: The chillers have the following direct interface with the Building Automation System (BAS) provided and wired by the BAS supplier:
   a. Flow sensor on the return water connection to the chiller to verify chilled water flow.
   b. Chiller enable interface from the BAS.
   c. Chilled water system temperature setpoint reset from the BAS.
   d. Demand limiting function from the BAS.
   e. Alarm output function from the chiller to the BAS.
   f. Pumps motor starter status interface via current sensing switches to the BAS.
   g. Pumps VSD interface to the BAS:
      1.) Start/Stop (digital output).
      2.) Run Status (digital input).
      3.) Speed Control (analog output).
      4.) Alarm (digital input).
      5.) Speed Feedback (analog input).
3. Sequence:
   a. Chiller Control: The chillers shall operate on factory furnished capacity and safety controls. The chiller sequencing software shall perform the following control strategies:
      1.) Start the chillers after primary and secondary chilled water flows are proven.
      2.) Stage chiller to match system cooling demand. The chiller shall be selected by the BAS based on operator selection or run-time; when multiple chillers
are required to meet heating demand, the chillers factory controller(s) shall optimize operating capacity for system efficiency.

3.) Incorporate chilled water system temperature setpoint reset based on cooling load demand.

4.) The chillers shall be selected by the BAS based on operator selection or run-time.

5.) Fail safe controls - Operate chiller subject to fail safe controls provided with the chiller by the unit Manufacturer and generate alarm conditions on local control panel furnished with chiller and remotely via the BAS.

6.) Refer to Section 236426, Natural Gas-Fired Engine Driven Chillers and Section 230900, Instrumentation and Control for HVAC.

b. Chilled Water Pump Control:
   1.) The primary chilled water pumps shall be selected by the BAS based on operator selection or run-time, and shall operate at variable volume.
   2.) The secondary chilled water pumps shall be selected by the BAS based on operator selection or run-time.
   3.) On a demand for cooling, the lead primary pump will be energized and its operation will be confirmed by in line flow sensor and current sensing switch. If the lead primary pump fails to start, the lag pump shall be started and an alarm shall be generated. The lead secondary pump shall then be energized and confirmed by flow sensor current sensing switch provided by the BAS. If the lead secondary pump fails to start, the lag pump shall be started and an alarm shall be generated.
   4.) With both the primary and secondary pumps started the chilled enable contact shall be closed and the chiller shall start.
   5.) The secondary chilled water pump speed shall be modulated to maintain a constant differential pressure at a remote point in the distribution system as indicated on the drawings.

c. Temperature Control:
   1.) Temperature sensors shall be installed and wired to the BAS for primary chilled water supply, primary chilled water return, secondary chilled water supply and secondary chilled water return.
   2.) The chiller controls shall be by the chiller manufacturer.
   3.) The design system chilled water supply setpoint shall be 44°F (adjustable).
   4.) Accessories: The BAS shall monitor and indicate if the chiller is in the alarm mode.

C. Waste Heat Recovery Heat Exchanger:

1. The waste heat exchanger shall be operated whenever the NG engine driven chillers are operating, and there is a simultaneous call for cooling and for heating.

2. General: The waste heat recovery heat exchanger shall have the following direct interface with the Building Automation System (BAS) provided and wired by the BAS supplier:
   a. Waste heat recovery loop control valves enable interface from the BAS.
   b. Waste heat recovery loop pumps enable interface from the BAS.

3. Sequence:
   a. The BAS system shall confirm the NG chiller(s) are started and operating.
   b. The system shall confirm there is a call for simultaneous HHW reheat (i.e., VAV terminals, AHUs, dehumidification, etc.).
   c. The system shall open the control valve and start waste heat recovery pump on the NG chiller side.
   d. The system shall simultaneously open the control valve and start waste heat recovery pump on the HHW system side.
e. Temperature Control: Temperature sensors shall be installed and wired to the BAS for waste heat supply and return to/from the NG chillers.
f. Temperature Control: Temperature sensors shall be installed and wired to the BAS for waste heat supply and return to/from the heating hot water system.
g. The waste heat recovery heat exchanger loop shall continue to operate until there is no longer a call for heating.

3.3 CONDENSER WATER SYSTEM (CT-1, CT-2, CWP-1,2)

A. General: The condenser water system shall consist of the following:
   1. Two induced draft, counter-flow cooling towers (CT-1, CT-2).
   2. Tower fans with variable speed drives.
   3. Variable speed condenser water pumps (CWP-1, CWP-2).
   4. Condenser Water Treatment System.

B. Condenser water/chiller Interface:
   1. The condenser water system shall be operated during the cooling season only. The equipment shall be winterized and shut down during the heating season. Schedules for chilled water system operation and shut down shall be provided by the Owner.
   2. General: The condenser water system and the chilled water system controls shall be interfaced through the BAS and wired by the BAS supplier:
      a. Flow sensor on the return water connection to the chiller to verify chilled water flow.
      b. Cooling towers enable interface from the BAS.
      c. Condenser water temperature reset from the BAS.
      d. Demand limiting function from the BAS.
      e. Tower fans and condenser water pumps VSD interface to the BAS:
         1.) Start/Stop (digital output).
         2.) Run Status (digital input).
         3.) Speed Control (analog output).
         4.) Alarm (digital input).
         5.) Speed Feedback (analog input).

C. Cooling Tower Control:
   1. Provide controller (without automatic reset) with sensor located in condenser water supply to modulate valve and cooling tower fan(s) in sequence and maintain required condenser water temperature. On rise in temperature, position valve to allow flow to tower; on further rise in temperature, start cooling tower fans(s). On fall in water temperature, reverse cycle.
   2. Start the cooling tower fan(s) after condenser water flows are proven.
   3. Factory mounted vibration switch on the fan gear box shall sense any excessive vibration and shall shut down the tower fan. An alarm notification shall be sent to the operator workstation if the fan is shut down due to excessive vibration.
   4. Stage cooling towers to match system chillers heat rejection demand.
   5. The cooling towers shall be selected by the BAS based on operator selection or run-time.
6. Provide pipe line tracing, wiring and controls to prevent domestic makeup water from freezing.

D. Condenser Water Pump Control:
   1. The condenser water pumps shall be selected by the BAS based on operator selection or run-time, and shall operate at variable volume.
   2. On a demand for heat rejection by the chillers, the lead condenser water pump will be energized and its operation will be confirmed by in line flow sensor and current sensing switch. If the lead primary pump fails to start, the lag pump shall be started and an alarm shall be generated. The lead secondary pump shall then be energized and confirmed by flow sensor current sensing switch provided by the BAS. If the lead secondary pump fails to start, the lag pump shall be started and an alarm shall be generated.
   3. With the condenser water pump started the condenser water system enable contact shall be closed and the cooling tower(s) shall start.
   4. The condenser water pump speed shall be modulated to provide scheduled capacity flows based on chilled water system demand. Condenser water pump speed shall be reduced to the minimum flow set by chiller requirements when possible, and as determined by cooling load requirement.

3.4 HYDRONIC HEATING SYSTEM (B-1/HHWP-1, B-2/HWHP-2, B-3/HWHP-3, HWWP-4, HWWP-5)

A. General: The hydronic heating shall consist of the following:
   1. Three high efficiency condensing hot water boilers (B-1, B-2, B-3).
   2. Boiler operating panel(s).
   3. Boiler Pump (for each boiler) - constant flow (HHWP-1, HHWP-2, HHWP-3).
   4. Primary hot water circulating pumps - variable flow (HHWP-4, HHWP-5).

B. Boiler Control Interface:
   1. The heating hot water system shall be operated year round to provide heating during the winter season, and terminal box reheat and dehumidification control during the cooling season. Schedules for hot water system operation shall be provided by the Owner.
   2. General: The boilers have the following direct interface with the Building Automation System (BAS) provided and wired by the BAS supplier:
      a. Boilers enable interface from the BAS.
      b. Hot water system temperature setpoint reset from the BAS.
      c. The boiler shall be selected by the BAS based on operator selection or run-time; when multiple boilers are required to meet heating demand, the boiler factory controller(s) shall optimize boilers operating capacity for system efficiency.
      d. Alarm output function from the boilers to the BAS.
      e. Pumps motor starter status interface via current sensing switches to the BAS.
      f. Pumps VSD interface to the BAS:
         1.) Start/Stop (digital output).
         2.) Run Status (digital input).
         3.) Speed Control (analog output).
         4.) Alarm (digital input).
         5.) Speed Feedback (analog input).
C. Emergency Burner Control: Provide emergency burner switches to interrupt fuel feed to burner(s).

D. Sequences:

1. Primary Hot Water Pump Control:
   a. The lead primary hot water pump shall be selected by the BAS based on operator selection or run-time. When outdoor temperature drops below 65°F (adjustable) the hot water pump shall be energized. If pump fails to start the lag pump shall be energized and an alarm signal generated.
   b. When the lead pump has proven operation for at least one minute (adjustable), the lead boiler and its associated boiler pump shall be selected by the BAS. If either the boiler or pump fails to start, the next boiler and associated boiler pump shall be energized and an alarm signal generated. The boiler manufacturer’s control panel shall control the boilers. Provide all necessary control devices and wiring necessary for the control panel to operate the boilers and respective boiler pumps.

2. Secondary Hot Water Pump Control:
   a. The lead secondary hot water pump shall be selected by the BAS based on operator selection or run-time. When the primary pump and boiler are started, the secondary hot water pump shall be energized. If pump fails to start the lag pump shall be energized and an alarm signal generated.
   b. The secondary pump speed shall be modulated to maintain a constant differential pressure at a remote point in the distribution system as indicated on the drawings.

3. Temperature Control:
   a. Temperature sensors shall be installed and wired to the BAS for hot water supply and hot water return. The boiler operating panel(s) shall control set points.
   b. A temperature sensor shall be installed and wired to the BAS for unrestricted bypass temperature for monitoring.
   c. The DDC system shall send the boiler operating panel a 4-20 ma signal for hot water reset based on outside ambient temperature. The hot water temperature shall be ramped from 130°F (adjustable) degrees when the outdoor air temperature is 60°F to 150°F (adjustable) when the outdoor temperature is 20°F or below.

<table>
<thead>
<tr>
<th>Ambient Air Temperature</th>
<th>Heating Hot Water Supply Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°F</td>
<td>130°F (adjustable)</td>
</tr>
<tr>
<td>60°F</td>
<td>90°F (adjustable)</td>
</tr>
</tbody>
</table>

d. If the heating hot water supply temperature varies by more than 10°F (adjustable) from setpoint, an alarm shall be generated.

e. The BAS shall monitor the alarm status of the boiler’s on board controller and initiate a BAS alarm.

f. During heating season electrical blackouts, the lead building distribution pump and the boiler pumps shall operate at full speed. When power is restored, the system shall revert to normal.

1.) Provide a means to allow only an actual power outage to engage the emergency heating sequence. Generator test starts and maintenance runs shall not engage the emergency heating sequence.
3.5 VARIABLE AIR VOLUME AIR HANDLING UNITS WITH ECONOMIZER, IN-LINE CENTRIFUGAL RETURN FANS AND HOT WATER COIL RECIRCULATION PUMPS (AHU-1/RF-1/HRP-1 AHU-2/RF-2/HRP-2)

A. General: The air handling unit shall consist of a supply fan with VSD, chilled water cooling coil, a hot water coil with freeze protection coil recirculation pump, filter/mixing box and economizer control. The return fan shall be duct mounted in-line fan and shall operate with the air handler. Separate damper actuators shall be provided for the unit dampers to control the return, exhaust and outdoor air dampers.

1. Original Main Building VAV air handling unit with return fan and hot water coil recirculation pump (AHU-1, RF-1, HRP-1).

2. Office Building Addition & Shops VAV air handling unit with return fan and hot water coil recirculation pump (AHU-2, RF-2, HRP-2).

B. Sequences:

1. General: The air handling unit fan and return fan motors shall be energized and de-energized via variable speed drives interfaced to the BAS.

2. Air handlers fan supply fans VSD and return fans VSD interface to the BAS.
   a. Start/Stop (digital output).
   b. Run Status (digital input).
   c. Speed Control (analog output).
   d. Alarm (digital input).
   e. Speed Feedback (analog input).

3. The air handling units shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Optimization programming shall determine start time of occupancy mode.

4. Shut Down/Start Up:
   a. Shut down: The air handling unit fans shall be de-energized, the outdoor air damper shall close and return air damper shall open (via spring return actuator(s)), and the exhaust air damper shall close (via spring return actuator) under the following conditions:
      1.) The air handling unit is turned off through the BAS.
      2.) The air handling unit is turned off by the fire alarm panel. The fan drives shall de-energize independently of the BAS and the position of the supply fan controls.
      3.) The air handling unit is turned off using the selector switch on the VSD fan controls.
      4.) Low Temperature Limit Shut down: If a low temperature limit up stream of the cooling coil senses a temperature below 37° (adjustable), the air handling unit fans shall be de-energized independent of the selector switch position, the outdoor air damper shall close and return air damper shall open (via spring return actuator(s)), the exhaust air damper shall close (via spring return actuator), and the hot water valve shall return to the full open position. Provide one restart through BAS software. Manual reset shall be required on subsequent low temperature alarm condition. The low temperature limit shall be serpentine on the outlet side of the hot water coil.
   b. Start up: The air handling unit fans and dampers shall be energized when all the following conditions are met:
1.) The air handling unit is turned on during the occupied mode through the Building Management System.
2.) Low temperature limit(s) are above 37°F (adjustable).
3.) The supply fan variable frequency drive starter is in the "Run" or "Auto" position.

5. Temperature Control:
   a. Temperature Sensing: Temperature sensors shall be installed in the supply, return, outside and mixed air streams. Temperature sensors shall be installed at the discharge of the hot water heating coil and the chilled water cooling coil.
   b. Space temperature sensors shall be provided to control the unit speed and discharge temperature as indicated below.
   c. Temperature Setpoint: The air handling unit heating and cooling controls shall modulate to maintain a discharge air temperature of 55 °F (adjustable) when the average space temperature is above 70°F (adjustable). When the average space temperature is below 70 °F (adjustable), the discharge air temperature shall be reset to 80°F (adjustable). The air handling unit speed shall be modulated to maintain space temperature. The air handler shall increase speed to deliver more 55 degree or 80 degree air to the space and then shall modulate back to the minimum air volume that will maintain space temperature. Once the air handler has reached minimum air flow, the 55°F (adjustable) discharge shall ramp up and the 80°F (adjustable) discharge ramp down to prevent over cooling or overheating.

6. Dehumidification Control:
   a. Humidity Sensing: Humidity sensors shall be installed in the supply and return air streams. Humidity sensor shall be installed at the discharge of the chilled water cooling coil.
   b. Humidity Setpoint: Return air humidity shall be measured by the BAS. Whenever return air humidity is above setpoint of 50% RH (adjustable) +/-10% RH (adjustable), the cooling coil valve shall be modulated open to reduce unit supply air humidity. VAV terminal reheat coil valves shall modulate as necessary to maintain the desire space temperature.

7. Demand Control Ventilation Control: Demand Ventilation shall proportionally modulate the outside air damper from maximum occupied ventilation position to minimum as shown below. Economizer control shall have priority over demand ventilation.

<table>
<thead>
<tr>
<th>Unit</th>
<th>CO2 level</th>
<th>Outside Air Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU-1</td>
<td>600 ppm</td>
<td>cfm</td>
</tr>
<tr>
<td></td>
<td>200 ppm</td>
<td>cfm</td>
</tr>
<tr>
<td>AHU-2</td>
<td>600 ppm</td>
<td>cfm</td>
</tr>
<tr>
<td></td>
<td>200 ppm</td>
<td>cfm</td>
</tr>
</tbody>
</table>

8. Monitor the unit’s filter differential pressure switch and generate an alarm for dirty filters (default - 0.5” WC, adjustable, above clean filter). Monitor the unit's

9. Safety Controls:
   a. The supply air or return air duct smoke detectors auxiliary contacts shall be hard-wired into the respective unit’s fan control circuits to shut down the fans upon activation. Shut down fans and close outdoor and exhaust air dampers whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.
b. Provide manual reset freeze stat to prevent unit operation if coil discharge air temperature drops below setpoint 40°F (adjustable). Locate downstream of heating coil.

c. When outside air temperature falls to 45°F (adjustable), the BAS shall start the hot water coil recirculation pump. The BAS shall monitor pump operation via a current sensing switch. If the pump does not start, an alarm shall be generated, the outside air damper shall be closed.

10. Occupied Mode:

a. The heating coil control valve shall modulate to maintain the discharge air temperature setpoint 55°F (adjustable).
1.) The heating coil control valve shall fail normally open upon a loss of power. Upon power failure, the normally open valve shall allow flow through the coil.

b. The cooling coil control valve shall modulate to maintain the discharge air temperature setpoint 55°F (adjustable).
1.) Whenever an air handling unit’s return air relative humidity (RH) is below setpoint 50% (adjustable), the respective unit’s discharge air temperature shall be reset upward to maintain 80% to 95% airflow through the VAV box with the most cooling demand. If airflow through the most demanding VAV box drops below 80%, the discharge air temperature shall be reset to 65°F (adjustable). If airflow through the most demanding VAV box rises toward 95%, the discharge air temperature shall be reset to 55°F (adjustable).

c. Economizer Mode: Provide differential enthalpy economizer operation to modulate outside air and return air dampers from minimum outdoor air position to 100% outdoor air to maintain space temperature setpoint. When the outdoor air enthalpy is less than the return air enthalpy the economizer mode shall be permitted to operate. The outdoor air, return air and exhaust air dampers shall be modulated to provide the supply air temperature set point. If additional cooling is required to achieve the desired supply air temperature set point the cooling mode shall also be permitted to operate. The air dampers shall be at the minimum ventilation position if the enthalpy of the outdoor air exceeds the enthalpy of the return air. Provide mixed air low limit control to prevent mixed air temperature from dropping below the discharge air temperature setpoint.

d. Minimum ventilation air volumes shall be set based on the air flows indicated on the drawings and equipment schedules.

e. Fans: The fan(s) shall operate continuously during occupied hours to provide ventilation.

11. Unoccupied Mode: During Unoccupied mode, the supply and return fans shall stop, the outside and exhaust air dampers shall close and the return air damper shall fully open, unless night purge is active. The heating coil control valve shall not fully close, and shall remain open to an operator defined minimum (default – 5%, adjustable) to prevent the AHU coils from freezing. Each unit shall have its own minimum adjustable valve position.

a. Whenever any space temperature drops below the unoccupied setpoint temperature 60°F (adjustable), the respective unit’s supply fan shall operate at full airflow and the heating coil control valve shall fully open. The supply fan shall stop and the coil valve shall close to minimum when all spaces reach the unoccupied setpoint temperature.
1.) Provide an adjustable time delay to prevent the supply fan from starting again until time delay has expired (default - 15 minutes). If the number of supply fan cycles exceeds an operator adjustable maximum cycles (default - 8) during an unoccupied period, the fan shall run continuously until the end of the next scheduled occupied period.
b. Night Purge shall be enabled whenever the average of space temperatures for a respective air handling unit system is above 75 °F (adjustable), the outdoor air temperature is above 50°F (adjustable) and the outdoor air dewpoint is below 60°F (adjustable). During Night Purge the outside air and exhaust air dampers shall fully open, and the supply and exhaust fans shall operate continuously at full airflow. Night Purge shall cease whenever the average space temperature drops below 75°F (adjustable), or the outdoor air temperature drops below 50°F (adjustable), or the outdoor air dewpoint rises above 60°F (adjustable), or the outdoor air temperature is less than 5°F (adjustable) cooler than the average space temperature.

c. Upon activation of the unoccupied mode override, the unit control shall revert to occupied mode operation for an operator defined interval (default – 2 hours, adjustable).

12. Fan Speed Control:
  a. Duct Static Pressure Sensing: A duct mounted differential pressure sensor (DPS) shall be installed at 2/3 distance; locate at 2/3 distance in system longest duct run, or at 2/3 distance in duct run with highest static pressure drop.  
  b. Unit Air Flow Measurement: An air flow monitoring station (AFM) shall be installed in the air handler supply fan inlet to provide air handling unit flow rate CFM.
  c. Speed Set point:
     1.) The supply fan variable frequency drive shall vary the supply fan speed to maintain the duct static pressure setpoint, which shall be automatically reset to meet zone airflow demands.
     2.) The return air fan VSD shall modulate to maintain constant supply/return CFM differential through a fan tracking program.
  d. Alarms to be generated at low speed and at high speed as sensed by the fan VSD.

13. During Warmup, the outside and exhaust air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the heating coil control valve shall be closed and the VAV box reheat coils shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

14. During Cooldown, the outside and exhaust air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the cooling coil control valve shall modulate to maintain the occupied discharge air temperature setpoint and the respective system’s VAV boxes shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

15. Monitor the unit’s filter differential pressure switch and generate an alarm for dirty filters (default - 0.5” WC above clean filter, adjustable).

16. Optimum Start/Stop:
   a. Optimum Start: Delay equipment startup based on outdoor air temperature, space temperature, and system response to assure that comfort conditions can be reached exactly at the scheduled occupancy time and operates in both the heating and the cooling cycles. An adaptive algorithm shall be employed which automatically adjusts according to the previous day's program performance and shall automatically assign longer lead times for weekend and holiday shutdowns. During warm-up and cool-down mode of operation exhaust fans shall be off, unless otherwise indicated, outside air dampers shall be closed and air handling unit shall operate on 100% recirculation. Provide lockout of cool-down mode if chillers are disabled.
b. Optimum Stop: Optimum stop program shall be provided for utilizing stored energy (flywheel effect) to automatically accelerate the stop time as much as one hour based on the external load conditions and the rate of change of the occupied space with the energy source off.

17. Accessories:
   a. Air handling unit filter differential pressure switches shall alarm when a preset limit is exceeded (0.60” WC, adjustable).

3.6 PACKAGED DX ROOFTOP VARIABLE AIR VOLUME UNIT WITH ECONOMIZER (RTU-1)

A. General: The packaged rooftop air handling unit shall consist of a supply fan with VSD, direct expansion (DX) electric cooling coil, a natural gas heating furnace, filter/mixing box, an integral exhaust/relief air fan and an integral condenser section. Separate damper actuators shall be provided for the unit dampers to control the return, exhaust and outdoor air dampers.

1. Call Center, Dispatch, Network Rooms and Gas Controller Packaged Rooftop VAV air handling unit (RTU-1).

B. Sequences:

1. General: The air handling unit fan motor shall be energized and de-energized via variable speed drive interfaced to the BAS.

2. Packaged rooftop unit supply fan VSD interface to the BAS.
   a. Start/Stop (digital output).
   b. Run Status (digital input).
   c. Speed Control (analog output).
   d. Alarm (digital input).
   e. Speed Feedback (analog input).

3. The packaged rooftop air handling unit shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Optimization programming shall determine start time of occupancy mode.

4. Shut Down/Start Up:
   a. Shut down: The air handling unit fans shall be de-energized, the outdoor air damper shall close and return air damper shall open (via spring return actuator(s)), and the exhaust air damper shall close (via spring return actuator) under the following conditions:
      1.) The air handling unit is turned off through the BAS.
      2.) The air handling unit is turned off by the fire alarm panel. The fan drive shall de-energize independently of the BAS and the position of the supply fan controls.
      3.) The air handling unit is turned off using the selector switch on the VSD fan controls.
      4.) Low Temperature Limit Shut down: If a low temperature limit up stream of the cooling coil senses a temperature below 37° (adjustable), the air handling unit fans shall be de-energized independent of the selector switch position, the outdoor air damper shall close and return air damper shall open (via spring return actuator(s)), the exhaust air damper shall close (via spring return actuator), and the natural gas heater shall be enabled. Provide one restart through BAS software. Manual reset shall be required on
subsequent low temperature alarm condition. The low temperature limit shall be serpentinened on the outlet side of the hot water coil.

b. Start up: The air handling unit fans and dampers shall be energized when all the following conditions are met:
   1.) The air handling unit is turned on during the occupied mode through the Building Management System.
   2.) Low temperature limit(s) are above 37°F (adjustable).
   3.) The supply fan variable frequency drive starter is in the "Run" or "Auto" position.

5. Temperature Control:
   1.) Temperature Sensing: Temperature sensors shall be installed in the supply, return, outside and mixed air streams. Temperature sensors shall be installed at the discharge of the natural gas heating section and the DX refrigerant cooling coil.
   2.) Space temperature sensors shall be provided to control the unit speed and discharge temperature as indicated below.
   3.) Temperature Setpoint: The air handling unit heating and cooling controls shall modulate to maintain a discharge air temperature of 55°F (adjustable) when the average space temperature is above 70°F (adjustable). When the average space temperature is below 70°F (adjustable), the discharge air temperature shall be reset to 80°F (adjustable). The air handling unit speed shall be modulated to maintain space temperature. The air handler shall increase speed to deliver more 55 degree or 80 degree air to the space and then shall modulate back to the minimum air volume that will maintain space temperature. Once the air handler has reached minimum air flow, the 55°F (adjustable) discharge shall ramp up and the 80°F (adjustable) discharge ramp down to prevent over cooling or overheating.

6. Dehumidification Control:
   1.) Humidity Sensing: Humidity sensors shall be installed in the supply and return air streams. Humidity sensor shall be installed at the discharge of the chilled water cooling coil.
   2.) Humidity Setpoint: Return air humidity shall be measured by the BAS. Whenever return air humidity is above setpoint of 50% RH (adjustable) +/- 10% RH (adjustable), the cooling coil valve shall be modulated open to reduce unit supply air humidity. VAV terminal reheat coil valves shall modulate as necessary to maintain the desire space temperature.

7. Demand Control Ventilation Control: Demand Ventilation shall proportionally modulate the outside air damper from maximum occupied ventilation position to minimum as shown below. Economizer control shall have priority over demand ventilation.

<table>
<thead>
<tr>
<th>Unit</th>
<th>CO2 level</th>
<th>Outside Air Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTU-1</td>
<td>600 ppm</td>
<td>cfm</td>
</tr>
<tr>
<td></td>
<td>200 ppm</td>
<td>cfm</td>
</tr>
</tbody>
</table>

8. Monitor the unit’s filter differential pressure switch and generate an alarm for dirty filters (default - 0.5” WC, adjustable, above clean filter).

9. Safety Controls:
   a. The return air duct smoke detector auxiliary contacts shall be hard-wired into the respective unit’s fan control circuits to shut down the fans upon activation.
Shut down fans and close outdoor and exhaust air dampers whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.

b. Provide manual reset freeze stat to prevent unit operation if coil discharge air temperature drops below setpoint 40°F (adjustable). Locate downstream of heating coil.

c. Rooftop unit supply fan shall continue to run until temperature in duct falls below predetermined adjustable setting.

10. Occupied Mode:

a. The natural gas heating section shall modulate to maintain the discharge air temperature setpoint 55°F (adjustable).

   1.) The natural gas heat shall fail normally off upon a loss of power.

b. The DX cooling coil refrigeration capacity shall cycle stages of cooling to maintain the discharge air temperature setpoint 55°F (adjustable).

   1.) Whenever an air handling unit’s return air relative humidity (RH) is below setpoint 50% (adjustable), the respective unit’s discharge air temperature shall be reset upward to maintain 80% to 95% airflow through the VAV box with the most cooling demand. If airflow through the most demanding VAV box drops below 80%, the discharge air temperature shall be reset to 65°F (adjustable). If airflow through the most demanding VAV box rises toward 95% the discharge air temperature shall be reset to 55°F (adjustable).

c. Economizer Mode: Provide differential enthalpy economizer operation to modulate outside air and return air dampers from minimum outdoor air position to 100% outdoor air to maintain space temperature setpoint. When the outdoor air enthalpy is less than the return air enthalpy the economizer mode shall be permitted to operate. The outdoor air, return air and exhaust air dampers shall be modulated to provide the supply air temperature set point. If additional cooling is required to achieve the desired supply air temperature set point the cooling mode shall also be permitted to operate. The air dampers shall be at the minimum ventilation position if the enthalpy of the outdoor air exceeds the enthalpy of the return air. Provide mixed air low limit control to prevent mixed air temperature from dropping below the discharge air temperature setpoint.

d. Minimum ventilation air volumes shall be set based on the air flows indicated on the drawings and equipment schedules.

e. Fans: The fan(s) shall operate continuously during occupied hours to provide ventilation.

11. Unoccupied Mode: During Unoccupied mode, the supply and exhaust fans shall stop, the outside and exhaust air dampers shall close and the return air damper shall fully open, unless night purge is active.

a. Whenever any space temperature drops below the unoccupied setpoint temperature 60°F (adjustable), the unit’s supply fan shall operate at full airflow and the natural gas heat section shall be enabled. The supply fan shall stop and the natural gas heat section shall be stopped when all spaces reach the unoccupied setpoint temperature.

   1.) Provide an adjustable time delay to prevent the supply fan from starting again until time delay has expired (default -15 minutes). If the number of supply fan cycles exceeds an operator adjustable maximum cycles (default -8) during an unoccupied period, the fan shall run continuously until the end of the next scheduled occupied period.

b. Night Purge shall be enabled whenever the average of space temperatures for a respective air handling unit system is above 75 °F (adjustable), the outdoor air temperature is above 50°F (adjustable) and the outdoor air dewpoint is below 60°F (adjustable). During Night Purge the outside air and exhaust air dampers
shall fully open, and the supply and exhaust fans shall operate continuously at full airflow. Night Purge shall cease whenever the average space temperature drops below 75°F (adjustable), or the outdoor air temperature drops below 50°F (adjustable), or the outdoor air dewpoint rises above 60°F (adjustable), or the outdoor air temperature is less than 5°F (adjustable) cooler than the average space temperature.
c. Upon activation of the unoccupied mode override, the unit control shall revert to occupied mode operation for an operator defined interval (default – 2 hours, adjustable).

12. Fan Speed Control:
a. Duct Static Pressure Sensing: A duct mounted differential pressure sensor (DPS) shall be installed at 2/3 distance; locate at 2/3 distance in system longest duct run, or at 2/3 distance in duct run with highest static pressure drop.
b. Unit Air Flow Measurement: An air flow monitoring station (AFM) shall be installed in the air handler supply fan inlet to provide air handling unit flow rate CFM.
c. Speed Set point:
1.) The supply fan variable frequency drive shall vary the supply fan speed to maintain the duct static pressure setpoint, which shall be automatically reset to meet zone airflow demands.
2.) The return air fan VSD shall modulate to maintain constant supply/return CFM differential through a fan tracking program.
d. Alarms to be generated at low speed and at high speed as sensed by the fan VSD.

13. During Warmup, the outside and exhaust air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the heating coil control valve shall be closed and the VAV box reheat coils shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

14. During Cooldown, the outside and exhaust air dampers shall be closed, the return air damper shall be fully open, the exhaust fan shall be off, the supply fan shall operate continuously, the cooling coil control valve shall modulate to maintain the occupied discharge air temperature setpoint and the respective system’s VAV boxes shall operate in occupied mode. When all spaces reach their occupied space temperature setpoint, the system shall revert to occupied mode operation.

15. Optimum Start/Stop:
a. Optimum Start: Delay equipment startup based on outdoor air temperature, space temperature, and system response to assure that comfort conditions can be reached exactly at the scheduled occupancy time and operates in both the heating and the cooling cycles. An adaptive algorithm shall be employed which automatically adjusts according to the previous day's program performance and shall automatically assign longer lead times for weekend and holiday shutdowns. During warm-up and cool-down mode of operation exhaust fans shall be on, unless otherwise indicated, outside air dampers shall be closed and air handling unit shall operate on 100% recirculation. Provide lockout of cool-down mode if chillers are disabled.
b. Optimum Stop: Optimum stop program shall be provided for utilizing stored energy (flywheel effect) to automatically accelerate the stop time as much as one hour based on the external load conditions and the rate of change of the occupied space with the energy source off.

16. Accessories:
a. Air handling unit filter differential pressure switches shall alarm when a preset limit is exceeded (0.60” WC, adjustable).
3.7 VARIABLE AIR VOLUME BOXES

A. General:

1. The VAV boxes shall be shut off type with hot water reheat, primary air valve with floating point electric motor actuator.

2. The air terminals shall operate in either Occupied, Unoccupied, Warmup or cooldown modes as scheduled.

3. The BAS supplier shall provide all necessary appurtenances such as 2-way or 3-way modulating hot water valves and actuators, sensors, relays, and control and communication wiring for a complete installation. Control transformers shall be furnished with VAV boxes.

4. Sequences:
   a. Temperature Control:
      1.) Sensors: Temperature sensors shall be supplied mounted and wired as shown on the drawings for each respective VAV box.
      2.) Temperature Set Points: Each VAV box shall be assigned an occupied temperature set point and throttling range, and an unoccupied set point and throttling range.
   b. Demand Control Ventilation:
      1.) Sensors: Carbon dioxide sensors shall be supplied mounted and wired as shown on the drawings for zone having DCV control and its respective VAV box.
      2.) CO2 Set Points: On a rise in space CO2 level above 900 PPM (adjustable), the VAV box damper modulate open to 75% (adjustable) of max air flow. If CO2 level remains above 900 PPM (adjustable) after 10 minutes (adjustable), or if VAV box damper was initially at or above 75% (adjustable) air flow, the damper shall open to maximum scheduled air flow, and the heating coil control valve shall modulate to satisfy the space temperature setpoint. On a drop in CO2 level below 800 PPM (adjustable) for 10 minutes (adjustable), the reverse sequence shall occur.
   c. Occupied Mode:
      1.) Heating Mode: On a drop in space temperature from setpoint, the VAV box shall be in minimum damper position and the heating coil control valve shall modulate to satisfy the space temperature setpoint. If VAV terminal leaving air temperature rises above 100°F (adjustable), modulate VAV air flow from minimum setpoint to heating airflow setpoint to maintain maximum leaving air temperature of 100°F (adjustable). For spaces with radiation heating, the radiation shall integrate with VAV box control.
      2.) Cooling Mode: On a rise in space temperature from setpoint, the VAV box damper shall modulate from minimum damper position to maximum cooling airflow to maintain the space setpoint temperature 76°F cooling (adjustable). The coil control valve shall be closed. When the space temperature is satisfied the damper shall be at minimum position.
      3.) For each VAV box, provide a heating mode damper position (adjustable) separate from the cooling mode minimum ventilation damper position.
d. Unoccupied Mode:
1.) The VAV box shall operate only as required to satisfy the sequences below.
2.) Night Cycle Mode shall apply to heating cycle only. The hot water pumps shall be energized and the hot water radiation, where available, shall be enabled to maintain a 60°F set point (adjustable). If the space temperature drops to 58°F (adjustable), the air handling unit shall be energized and the hot water reheat valve shall be opened until the space temperature reaches 60°F (adjustable), then the hot water reheat valve shall be closed and the air handling unit shall shut down.
3.) Night Purge Model shall only apply to cooling: modulate open unit set point is achieved and then modulated to maintain set point.

3.8 HEATING AND VENTILATION UNIT WITH EXHAUST FANS (HV-1, EF-11, EF-12)

A. General: The indoor heating and ventilation unit shall consist of a supply fan with VSD, a direct fired natural gas heating furnace, ducted combustion air and a filter/mixing box. Separate damper actuators shall be provided for the unit dampers to control the return, exhaust and outdoor air dampers. Associated exhaust fans shall ventilate the air being put into the space by the heating and ventilation unit.

1. Warehouse Heating and Ventilation air handling unit (HV-1)
2. Warehouse rooftop centrifugal downblast exhaust fans (EF-11, EF-12)

B. Sequences

1. General: The heating and ventilation unit fan motor shall be energized and de-energized via variable speed drive interfaced to the BAS. The exhaust fans shall be energized and de-energized via their motor starters interfaced to the BAS.
2. The heating and ventilation unit and associated exhaust fans shall operate in either Occupied, Unoccupied, Warmup or Cooldown modes as scheduled. Optimization programming shall determine start time of occupancy mode.
3. Shut Down/Start Up:
   a. Shut down: The heating and ventilation unit fan shall be de-energized, the outdoor air damper shall close, the return air damper shall open (via spring return actuator(s) and the exhaust fans shall be de-energized if operating under the following conditions:
      1.) The heating and ventilation unit is turned off through the BAS.
      2.) The associated exhaust fans are turned off through the BAS when there is a call for ventilation.
      3.) The heating and ventilation unit and associated fans are turned off by the fire alarm panel. The fan drive shall de-energize independently of the BAS and the position of the supply fan controls.
      4.) The heating and ventilation unit is turned off using the selector switch on the VSD fan controls.
   b. Start up: The heating and ventilation unit fan and dampers shall be energized, and the associated exhaust fans shall be started during a call for ventilation when all the following conditions are met:
      1.) The heating and ventilation unit is turned on during the occupied mode through the BAS.
2.) The associated exhaust fans are turned on during the occupied mode through the BAS.

3.) The supply fan variable frequency drive starter is in the "Run" or "Auto" position.

4. Temperature Control:
   a. Temperature Sensing: Temperature sensors shall be installed in the supply, outside and mixed air streams. Temperature sensor shall be installed at the discharge of the natural gas heating section.
   b. Space temperature sensor shall be provided to control the unit discharge temperature as indicated below.
   c. Temperature Setpoint - Heating: The unit controls shall modulate the natural gas section to maintain a space temperature setpoint of 65 °F (adjustable). During heating, the supply fan VSD shall be set to unit minimum air flow (adjustable), the outside air damper shall be at minimum outside air setting (adjustable), and the associated exhaust fans shall be de-energized.
      1.) Provide heat dissipation thermostat in supply duct to maintain fan operation until temperature in duct falls below predetermined setting
   d. Temperature Setpoint - Ventilation: During ventilation, the supply fan VSD shall be set to unit maximum air flow (adjustable), the outside air damper shall be at maximum outside air setting (adjustable), and the associated exhaust fans shall be energized. Intent is for system to operate to maintain a space temperature setpoint no greater than 10°F above outdoor ambient temperature.

5. Monitor the unit’s filter differential pressure switch and generate an alarm for dirty filters (default - 0.5” WC, adjustable, above clean filter).

6. Safety Controls:
   a. The return air duct smoke detector auxiliary contacts shall be hard-wired into the respective unit’s fan control circuits to shut down the fans upon activation. Shut down fans and close outdoor and exhaust air dampers whenever the building fire alarm is activated. Restart units when the alarm signal is cleared.
   b. Rooftop unit supply fan shall continue to run until temperature in duct falls below predetermined adjustable setting.

7. Occupied Mode:
   a. The natural gas heating section shall modulate to maintain the space temperature setpoint 65°F(adjustable). During heating, the supply fan shall operate continuously to provide minimum outside air.
   b. When space temperature is below control range of space temperature sensor, close outdoor air damper (use 100% return air), and enable natural gas heating.
      1.) The natural gas heat shall fail normally off upon a loss of power.
   c. Ventilation air volumes shall be set based on the air flows indicated on the drawings and equipment schedules. As space temperature rises into control range of space temperature sensor (adjustable), open outdoor air damper to predetermined minimum position. As temperature rises to space temperature sensor set point (adjustable), modulate natural gas heating off. On continued rise, modulate outdoor air damper open beyond its minimum position and energize associated exhaust fans to introduce atmospheric cooling.
   d. By means of adjustable discharge air temperature controller, located in unit discharge air, prevent supply air temperature from falling below 65°F (adjustable) by overriding space temperature setpoint to provide more heating and to decrease percentage of outside air.
8. **Unoccupied Mode:** During Unoccupied mode, the supply fan shall stop, the outside air damper shall close, the associated exhaust fans shall stop, and the return air damper shall fully open, unless night purge is active.

   a. Whenever the space temperature drops below the unoccupied setpoint temperature 60°F (adjustable), the unit’s supply fan shall operate at full airflow and the natural gas heat section shall be enabled. The supply fan shall stop and the natural gas heat section shall be stopped when the space reaches the unoccupied setpoint temperature.

      1.) Provide an adjustable time delay to prevent the supply fan from starting again until time delay has expired (default -15 minutes). If the number of supply fan cycles exceeds an operator adjustable maximum cycles (default - 8) during an unoccupied period, the fan shall run continuously until the end of the next scheduled occupied period.

   b. Night Purge shall be enabled whenever the space temperature is above 75 °F (adjustable), the outdoor air temperature is above 50°F (adjustable) and the outdoor air dewpoint is below 60°F (adjustable). During Night Purge the outside air and exhaust air dampers shall fully open, and the supply fan shall operate continuously at full airflow. Night Purge shall cease whenever the average space temperature drops below 75°F (adjustable), or the outdoor air temperature drops below 50°F (adjustable), or the outdoor air dewpoint rises above 60°F (adjustable), or the outdoor air temperature is less than 5°F (adjustable) cooler than the average space temperature.

   c. Upon activation of the unoccupied mode override, the unit control shall revert to occupied mode operation for an operator defined interval (default – 2 hours, adjustable).

9. **Fan Speed Control:**

   a. Speed Set point:

      1.) The supply fan variable speed drive shall operate fan at predetermined minimum air flows as scheduled on the drawings during heating.

      2.) The supply fan variable speed drive shall operate fan at predetermined maximum air flows as scheduled on the drawings during ventilation.

   b. Alarms to be generated at low speed and at high speed as sensed by the fan VSD.

10. **During Warmup,** the outside air damper shall be closed, the return air damper shall be fully open, the associated exhaust fans shall be off, the supply fan shall operate continuously and the natural gas heating section shall be enabled. For a predetermined time period (adjustable) prior to scheduled space occupancy, start heating and ventilation unit operating continuously on 100% return air with heating control to bring space temperature up to occupied level.

11. **During Cooldown,** the outside air damper shall be fully opened, the return air damper shall be fully closed, the associated exhaust fans shall be started and the supply fan shall operate continuously. For a predetermined time period (adjustable) prior to scheduled space occupancy, start heating and ventilation unit ventilators continuously on 100% outside air with associated exhaust fans and ventilation control to bring space temperature up to occupied level.

3.9 **SPLIT SYSTEM DX AIR CONDITIONER (AC-1/CU-1, AC-2/CU-2)**

   A. **General:** The cooling only DX split system air conditioner shall consist of a ceiling mounted cassette indoor air handler with wall mounted temperature sensor and integral condensate pump; the condensing unit shall be located outdoors on grade with a low ambient operation kit.
1. Server Room 1 sensible cooling only ceiling cassette air conditioning unit (AC-1/CU-2).
2. Server Room 2 sensible cooling only ceiling cassette air conditioning unit (AC-2/CU-2).

B. Sequences:

1. General: The split system direct expansion (DX) cooling only air conditioner AC-1 (indoor ceiling cassette unit) and CU-1 (outdoor rooftop mounted condensing unit) shall operate via a local wall mounted temperature sensor.

2. The DX split system air conditioners shall operate in Occupied mode continuously to maintain server room conditions.

3. Shut Down/Start Up:
   a. The DX split system indoor unit is started and stopped by the BAS.
   b. The DX split system outdoor unit is started and stopped by interconnecting wiring from the indoor unit.

4. Temperature Control:
   a. Temperature Sensing: Temperature sensor shall be installed in the space, wall mounted to control the unit speed and discharge temperature as indicated below.
   b. Temperature Setpoint: The ceiling cassette unit controls shall cycle stages of cooling capacity to maintain a space air temperature of 72°F (adjustable). Whenever there is a call for cooling via the BAS and the indoor unit is started, the associated outdoor condensing unit shall be started via interconnected control wiring.

5. Safety Controls:
   a. The BAS shall monitor DX factory alarm.
   b. The indoor unit integral condensate pump shall operate via factory controls; factory drain pan water level controls shall prevent unit from operating when condensate pump or drain fail to remove condensate.

3.10 FINNED TUBE RADIATION

A. General:

1. The finned tube radiation includes two way modulating control valve.
   a. Four wall mounted HHW fin tube radiators (FTR-1, FTR-2, FTR-3, FTR-4).

2. The BAS supplier shall provide all necessary appurtenances such as valve actuators, wall sensors, relays, and control and communication wiring for a complete installation.

3. Sequences:
   a. Temperature Control:
      1.) Sensors: Temperature sensors shall be supplied mounted and wired as shown on the drawings for each finned tube radiation section.
      2.) Temperature Set points: Each shall be assigned an occupied temperature set point and throttling range, and an unoccupied set point and throttling range.
      3.) Integrate as a secondary heat source for applications where primary heat is provided by air distribution
   b. Occupied Mode:
      1.) Heating Mode: Should the space temperature drop below set point 68°F (adjustable) a heating demand signal shall be generated to energize the hot
water pumps and the hot water valve shall modulate open to maintain set point.

c. Unoccupied Mode:
   1.) Night Cycle Mode shall apply to heating cycle only. The hot water pumps shall be energized and the hot water radiation, where available, shall be enabled to maintain a 60°F (adjustable) set point.
   2.) Night Purge Model shall only apply to cooling: Energize and de-energize unit at full cooling unit set point is achieved and then de-energize.

3.11 HOT WATER UNIT HEATERS

A. General: The heaters consist of a propeller type supply fan, a hot water heating coil and an integral adjustable face louver.

   1. Two propeller type HHW unit heaters, wall mounted (UH-1, UH-2).

B. The BAS supplier shall provide all necessary appurtenances such as all sensors, relays, and control and communication wiring for a complete installation.

C. Sequences:

   1. General: The fan motors shall be energized and de-energized via the Building Management System.

   2. Shut Down/Start Up:
      a. Shut down: The cabinet heater fans shall be de-energized under the following conditions:
         1.) The heater is turned off through the Building Management System.
         2.) The heater is turned off using the selector switch on the start H-O-A switch.
      b. Start up: The heater fans shall be energized when all the following conditions are met:
         1.) The heater is turned on during the occupied mode through the Building Management System.
         2.) The starter is in the "Hand" or "Auto" position.
      c. Temperature Control:
         1.) Sensors: Temperature sensors shall be supplied mounted and wired as shown on the drawings.
         2.) Temperature Set points: Each cabinet heater shall be assigned a temperature set point and throttling range.
      d. Occupied Mode (note unoccupied mode does not pertain to these units):
         1.) Should the space temperature rise above set point the fan shall be de-energized.
         2.) Should the space temperature drop below set point, the fan shall be energized

3.12 EXHAUST FANS

A. General: The BAS supplier shall provide all necessary appurtenances such as dampers actuators, sensors, relays, and control and communication wiring for a complete installation. Exhaust systems shall include rooftop, inline or wall propeller fans as scheduled on the drawings.

B. Sequences:

   1. General: The fan motors shall be energized and de-energized via the BAS.
2. The exhaust and supply fans shall operate in either Occupied or Unoccupied modes as scheduled. Optimization programming shall determine start time of occupancy mode.

3. Upon detection of smoke or fire by fire alarm system device in area a fan is serving, the fans shall be turned off by the fire alarm control panel. The fan drives shall de-energize independently of the BAS and the position of the fan controls, and the associated spring return motorized damper (where applicable) shall be closed.

4. EF-1, EF-2, EF-3, EF-8: Rooftop curb mounted centrifugal downblast exhaust fans for toilets, janitor's closets and locker rooms exhaust shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.
   a. The BAS shall start/stop each exhaust fan.
   b. The BAS shall monitor fan operation/status via current sensing switch.
   c. Integral motorized damper shall be hardwire interlocked to open prior to fan start.
   d. The BAS shall monitor occupancy in all toilets via ceiling mounted occupancy sensors. The BAS shall start a toilet exhaust fan whenever its associated ceiling mounted occupancy sensor senses occupancy of the space. The fan shall run a minimum of ten minutes (adjustable) after the space is unoccupied as sensed by the occupancy sensor.

5. EF-4: Inline centrifugal two speed exhaust fan with for Electrical Room ventilation and temperature control shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.
   a. The BAS shall start/stop the exhaust fan.
   b. The BAS shall monitor fan operation/status via current sensing switch.
   c. Integral motorized damper shall be hardwire interlocked to open prior to fan start.
   d. The fan shall normally operate at scheduled minimum ventilation air flow rate. The BAS shall monitor space temperature via wall mounted temperature sensor. When the space temperature rises above a setpoint of (80°F) adjustable, the exhaust fan shall increase speed to operate at scheduled maximum ventilation air flow rate. When space temperature drops below 75°F (adjustable) for a 15 minute (adjustable) time period, the BAS shall de-energize the exhaust fan.

6. EF-5/L-9: Rooftop centrifugal downblast exhaust fan with makeup outside air intake louver for Elevator Machine Room ventilation and temperature control shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.
   a. The BAS shall start/stop the exhaust fan.
   b. The BAS shall monitor fan operation/status via current sensing switch.
   c. Integral fan motorized damper shall be hardwire interlocked to open prior to fan start.
   d. Associated makeup outside air intake louver with integral motorized damper shall be hardwire interlocked to open prior to fan start.
   e. The BAS shall monitor space temperature via wall mounted temperature sensor. When the space temperature rises above a setpoint of (80°F) adjustable, the exhaust fan shall be energized. When space temperature drops below 75°F (adjustable) for a 15 minute (adjustable) time period, the BAS shall de-energize the exhaust fan and close the louver damper.

7. EF-6, EF-13, SF-1/L-2: Inline centrifugal exhaust fan with wall propeller supply fan for Mechanical Room 3 and boiler room ventilation and temperature control shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.
   a. The BAS shall start/stop the exhaust fans and the supply fan.
   b. The BAS shall monitor fans operation/status via current sensing switches.
   c. Associated makeup outside air intake louver with integral motorized damper shall be hardwire interlocked to open prior to fan start.
d. The BAS shall monitor space temperatures via wall mounted temperature sensors. When the space temperature rises above a setpoint of (80°F) adjustable, the exhaust fans and supply fan shall be energized. When space temperature drops below 75°F (adjustable) for a 15 minute (adjustable) time period, the BAS shall de-energize the exhaust fans and supply fan.

e. The BAS shall monitor space carbon monoxide level in the boiler room via a wall mounted carbon monoxide sensor.

1.) On a rise above the carbon monoxide alarm limit of 25 ppm (adjustable), the BAS shall generate an alarm and the heating hot water system boilers shall be de-energized.

8. EF-7/L-8, SF-2/L-7: Wall propeller exhaust fan with wall propeller supply fan for Mechanical Room 2 ventilation shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.

a. The BAS shall start/stop the exhaust fans and the supply fan.

b. The BAS shall monitor fans operation/status via current sensing switches.

c. Associated makeup outside air intake louver and exhaust air louver with integral motorized dampers shall be hardware interlocked to open prior to their respective fan's start.

d. The BAS shall monitor space temperatures via wall mounted temperature sensors. When the space temperature rises above a setpoint of (80°F) adjustable, the exhaust fans and supply fan shall be energized. When space temperature drops below 75°F (adjustable) for a 15 minute (adjustable) time period, the BAS shall de-energize the exhaust fans and supply fan.

e. The BAS shall monitor space carbon monoxide level in the chiller room via a wall mounted carbon monoxide sensor.

1.) On a rise above the carbon monoxide alarm limit of 25 ppm (adjustable), the supply and exhaust fans shall operate at full airflow, and the condition shall be a system alarm. When the carbon monoxide concentration drops below the alarm limit (adjustable) for a 10 minute (adjustable) time period, the fans shall continue to operate for an additional 10 minute (adjustable) time period and then revert to scheduled operation.

f. A refrigerant leak detector shall monitor space for refrigerant leaks in the chiller room via multiple air quality sensors. The leak detector controller shall be hardware interlocked to the natural gas chillers and to the supply and exhaust fans.

1.) On a rise of detected refrigerant above the occupational exposure limit (OEL) of 1,000 PPM (adjustable), the supply and exhaust fans shall be started via hardware interlocks from the controller. The natural gas chillers shall be stopped via their normal shutdown sequence, and the condition shall be a system alarm. The fans shall continue to operate until manually reset at leak detector controller interface.

9. EF-9/L-11: Rooftop centrifugal upblast paint spray booth exhaust fan with explosion proof motor and makeup outside air intake louver in Shop Area Work Room shall operate whenever started by dedicated manual wall mounted hand switch.

a. A wall mounted hand switch shall start/stop the exhaust fan.

b. The BAS shall monitor fan operation/status via current sensing switch.

c. Integral fan motorized damper shall be hardware interlocked to open prior to fan start.

d. Associated makeup outside air intake louver with integral motorized damper shall be hardware interlocked to open prior to fan start.

e. The fan shall continue to run for a 5 minute (adjustable) time period via a time delay relay after the hand switch is turned to the "Off" position.
10. **EF-10**: Rooftop curb mounted centrifugal downblast exhaust fans for Glove Wash and Glove Testing rooms shall operate continuously during occupied mode and shall be de-energized during unoccupied mode.
   a. The BAS shall start/stop each exhaust fan.
b. The BAS shall monitor fan operation/status via current sensing switch.
c. Integral motorized damper shall be hardwire interlocked to open prior to fan start.
d. The fan shall run continuously during occupied hours.

11. **Existing Welding Hood Exhaust Fan**: Rooftop centrifugal downblast welding hood exhaust fan is existing to remain. Hood fan is started by dedicated manual wall mounted hand switch.
   a. A wall mounted hand switch shall start/stop the exhaust fan.
b. The BAS shall monitor fan operation/status via current sensing switch.

12. **Existing Lawn Equipment Repair Hood Exhaust Fan**: Rooftop centrifugal downblast lawn equipment repair hood exhaust fan is existing to remain. Hood fan is started by dedicated manual wall mounted hand switch.
   a. A wall mounted hand switch shall start/stop the exhaust fan.
b. The BAS shall monitor fan operation/status via current sensing switch.

### 3.13 COMBUSTION AIR SYSTEM CONTROL

**A.** Combustion Air Control; Gravity:

1. Provide natural gas chillers outdoor combustion air damper to open automatically whenever chillers(s) start, and to close when chillers(s) stop. Motorized damper shall be hardwire interlocked with natural gas chillers operation.

2. Provide existing natural gas domestic hot water heater outdoor combustion air damper to open automatically whenever burner(s) start, and to close when burner(s) stop. Motorized damper shall be hardwire interlocked with domestic water heater operation.

### 3.14 OUTSIDE AIR MONITORING

**A.** The BAS shall monitor outside temperature, humidity and carbon dioxide (CO2) levels via a dedicated outside weather station.

**B.** Provide the inputs for monitoring and use as required by systems, individual equipment and terminal unit operating sequences.

### 3.15 UTILITY MONITORING

**A.** The BAS shall log and trend electrical utility meter information. Logs and reports configuration and content shall be coordinated with Owner requirements. For multiple meters, provide separate log/trend reports.

**B.** The BAS shall log and trend gas utility meter information. Logs and reports configuration and content shall be coordinated with Owner requirements. For multiple meters, provide separate log/trend reports.

**C.** The BAS shall log and trend water utility meter information. Logs and reports configuration and content shall be coordinated with Owner requirements. For multiple meters, provide separate log/trend reports.

END OF SECTION
SECTION 232113 HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping systems for hot water heating, chilled water cooling, condenser water, make-up water for these systems, blow-down drain lines, and condensate drain piping. Piping materials and equipment specified in this Section include pipes and fittings.

1.2 SUBMITTALS

A. Welders’ certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

B. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe and fittings.

C. Reports specified in Part 3 of this Section.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: comply with the provisions of the following:

1. ASME B 31.9 “Building Services Piping” for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.


PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All piping and fittings shall be manufactured in the United States of American or Canada.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 Article “PIPE APPLICATIONS” for identification of where the below materials are used.

B. Drawn Temper Copper Tubing: ASTM B 88, Type L.

C. Annealed Temper Copper Tubing: ASTM B 88, Type K.

D. Steel Pipe: ASTM A 53, Schedule 40, seamless, black steel pipe, plane ends.

2.3 FITTINGS

A. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

C. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

D. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

E. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.

F. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.

G. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
   2. End Connections: Butt Welding.
   3. Facings: Raised face.


2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8, Classification BAg 1 (Silver).
   1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

B. Welding Materials: Comply, with Section II, Part C. ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

C. Gasket Material: thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.

PART 3 - EXECUTION

3.1 PIPE APPLICATIONS

A. Install Type L, drawn copper tubing with wrought copper fittings and solder joints for 2 inch and smaller, above ground, within building. Install Type K, annealed temper copper tubing for 2 inch and smaller without joints, below ground or within slabs.

B. Install steel pipe with flanged or welded joints for 2-1/2 inch and larger.

3.2 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and all branch connections.
C. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

E. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1” clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

F. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

G. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4” ball valve, and 3/4” threaded shoulder nipple and cap.

H. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

I. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.

J. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

K. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

L. Install branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line.

M. Install unions in pipes 2 inch and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

N. Install dielectric fittings to join dissimilar metals.

O. Install flanges on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

P. Install flexible connectors at inlet and discharge connections to pumps (except inline pumps) and other vibration producing equipment.

Q. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 inch and larger.

R. Anchor piping to ensure proper direction of expansion and contraction.

3.3 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual.”

1. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
2. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.


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 threaded into joint.

2. Align threads at point of assembly.

3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
   a. 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. Welded Joints: Comply with the requirement in ASME Code B31.9 - “Building Services Piping.”

D. 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 using torque wrench.

3.4 FIELD QUALITY CONTROL

A. Preparation for testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:

1. Leave joints including welds uninsulated and exposed for examination during the test.

2. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.

4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.

5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Testing: Test hydronic piping as follows:

1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.

2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the liquid.
3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.

4. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength.

5. After the hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

3.5 ADJUSTING AND CLEANING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

C. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.6 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.

2. Remove and clean strainers.

3. Check pump for proper direction and correct improper wiring.

4. Set automatic fill valves for required system pressure.

5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type). Following completion of start-up, close all air vent stop cocks.

6. Set temperature controls so all coils are calling for full flow.

7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.

8. Lubricate motors and bearings.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes hydronic specialties.

1.2 SUBMITTALS

A. Product Data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.

1. Furnish flow and pressure drop curves for diverting fittings and calibrated-orifice balancing valves, based on manufacturer’s testing.

B. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual

C. Certification of compliance with ASTM and ANSI manufacturing requirements for hydronic specialties.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: comply with the provisions of the following:

1. ASME B 31.9 “Building Services Piping” for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

2. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 EXTRA STOCK

A. Maintenance Stock: Furnish a sufficient quantity of chemical for initial system start-up and for preventative maintenance for one year from Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one of the following:

1. Calibrated-Orifice, Balancing Valve:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco, Inc.

2. Safety Relief Valves:
   a. Amtrol, Inc.
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Spirax Sarco.
   d. Watts Regulator Co.
3. Pressure Reducing Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.

4. Air Vents (manual and automatic):
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Hoffman Specialty ITT; Fluid Handling Div.
   d. Spirax Sarco.

5. Air Separators:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.

6. Diaphragm-Type Expansion Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.

7. Pump Suction Diffusers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.
   e. Victaulic Company of America

8. Pump Discharge Valve (Triple Duty Valve):
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Taco, Inc.

9. Chemical Feeder:
   a. Culligan USA.
   b. Vulcan Laboratories, Subsidiary of Clow Corp.
   c. York-Shipley, Inc.

10. Y-Pattern Strainers:
    b. Hoffman Specialty ITT; Fluid Handling Div.
    c. Metraflex Co.
    d. Spirax Sarco.
    e. Trane Co.
    f. Victaulic Co. of America.
    g. Watts Regulator Co.

2.2 HYDRONIC SPECIALTIES

A. Calibrated-Orifice, Balancing Valve: Bronze body, 125 psig CWP, 250°F maximum operating temperature, with brass or stainless steel ball, PTFE seat, and calibrated orifice. Provide threaded or socket ends, integral pressure gage seals for differential pressure reading, and lever handle with memory stop. Valves shall be equal size to the supply and return piping line size.
B. Manual Air Vent: bronze body and nonferrous internal parts; 150 psig working pressure, 225°F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8 inch discharge connection and 1/2 inch inlet connection.

C. Automatic Air Vent: designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240°F operating temperature; and having 1/4 inch discharge connection and 1/2 inch inlet connection.

D. Diaphragm-Type Expansion Tanks: size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 375°F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1.

E. Air separator: welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and 375°F operating temperature; perforated stainless steel air collector tube tangential inlet and outlet connections; screwed connections up to and including 2" NPS; flanged connections for 1-1/2" NPS and above; threaded blowdown connection; sized as indicated for full system flow capacity.

F. Pump Suction Diffusers: cast-iron body, with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger; 175 psig working pressure, 300°F maximum operating temperature; and complete with the following features:

1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
3. Disposable fine mesh strainer to fit over cylinder strainer.
4. Permanent magnet, located in flow stream, removable for cleaning.
5. Adjustable foot support, designed to carry weight of suction piping.

G. Pump Discharge Valve, Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, ductile-iron body, pump-discharge fitting; with drain plug ad bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

H. Chemical Feeder: bypass type chemical feeders of 5 gallon capacity, welded steel construction; 125 psig working pressure; complete with fill funnel and inlet, outlet, and drain valves.

1. Chemicals shall be specially formulated to prevent accumulation of scale and corrosion in piping system and connected equipment, developed based on a water analysis of make-up water.

I. Y-Pattern Strainers: 125 psig working pressure cast-iron body (ASTM A 126, Class B), flanged ends for 2-1/2 inch and larger, threaded connections for 2 inch and smaller, bolted cover, perforated Type 304 stainless steel basket, and bottom drain connection.
PART 3 - EXECUTION

3.1 HYDRONIC SPECIALTIES INSTALLATION

A. Install calibrated-orifice balance valve where indicated on the Drawings.

B. Install automatic air vents at high points in the system, heat transfer coils, and elsewhere as required for system air venting. Provide drain pipe routed from vent to floor drain or plumbing fixture.

C. Install dip tube fittings in boiler outlet. Run piping to expansion tank with 1/4 inch per foot (2 percent) upward slope towards tank. Connect boiler outlet piping.

D. Install inline air separators in pump suction lines. Run piping to expansion tank with 1/4 inch per foot (2 percent) upward slope towards tank. Install drain valve on units 2 inch and larger.

E. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.

F. Install pump discharge valves in horizontal or vertical position with stem in upward position. Allow clearance above stem for check mechanism removal.

G. Install shot-type chemical feeders in each hydronic system where indicated; in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

H. Install diaphragm-type expansion tanks on floor as indicated. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements.

END OF SECTION
SECTION 232119 GLYCOL INJECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY
A. This section includes glycol injection system and glycol fluid.

1.2 SUBMITTALS
A. Product data.
B. Manufacturer’s descriptive literature, operating instructions, and maintenance and repair data.
C. Submit sample report indicating the chemical composition including but not limited to the following:
   1. Percent of glycol to water solution.
   2. Freeze protection temperature.
   3. pH level.
   4. Specific conductance.
   5. Chloride and Sulfide content.
D. Submit building water sample report (if applicable).

1.3 QUALITY ASSURANCE
A. After the system has been filled with the glycol solution, and circulated for a minimum of 7 days, the contractor shall obtain a glycol sampling kit from the supplier. The appropriate sample or samples shall be taken and forwarded to the supplier’s laboratory where the samples shall be tested and analyzed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER OF GLYCOL INJECTION SYSTEM
A. Liquid Metronics, Inc or equal.

2.2 MATERIALS
A. All equipment furnished under this section of the specification shall be UL listed and labeled.

1. Glycol injecting pump shall be positive displacement with adjustable output volume of 0 to 24 gallons per day at 80 PSIG without hydraulically backed diaphragm – 110 watts @ 115V. Pump shall be as manufactured by Liquid Metronics Inc. MOD #A-11-24 GPD or approved equal.

2. Tank shall be a 50 gallon rigid polyethylene self-supporting solution tank with fiberglass cover assembly as manufactured by LMI INC MOD #26350/50 or approved equal.

3. Include with pump package 16 feet of type “L” copper tubing with compression connections, a foot valve with integral one piece strainer for the suction line and an injection/anti9-syphon check valve with .5” NPT male connection for the injection point.
4. Provide site glass to provide visible indication of flow/no flow conditions – LMI INC
MODEL #LMI24614 or approved equal

5. Provide pump pressure switch(es) shall be as manufactured by Honeywell model
#L404A1396 or approved equal.

6. Provide liquid low level switch on the solution tank. Switch to be SPDT with contact ratings
for 1 H.P. at 115 volts. Switch shall be as manufactured by Penn Controls model #F63ACI.

2.3 FLUIDS

A. Glycol shall be of the propylene type with inhibitors manufactured especially for heating and cooling
systems. Glycol shall be colored type “DowFrost” as manufactured by the Dow Chemical Co.,
“Norkool” as manufactured by Union Carbide Co. or approved equal.

B. Glycol shall be of the ethylene type with inhibitors manufactured especially for heating and cooling
systems. Glycol shall be colored type “DowTherm SR-1” as manufactured by Dow Chemical Co.,
“Norkool” as manufactured by Union Carbide Co. or approved equal.

C. Water shall consist of the following options:
   1. Distilled water.
   2. De-ionized water.
   3. Glycol manufacturer’s premixed solution.
   4. Building raw water is acceptable contingent upon submittal and acceptance of water analysis
report indicating the chemical composition is in conformance with the requirements of the
glycol manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer’s installation instructions and recommendations.

B. Glycol shall not be injected until the piping system(s) have been tested, cleaned and flushed.

C. The contractor shall calculate and supply the volume of fluid required by the system(s) for the
percentage of glycol to water specified.

END OF SECTION
SECTION 232123  HVAC PUMPS

PART 1 - GENERAL

1.1  SUMMARY

A. This Section includes the following types of HVAC pumps:
   1. Inline circulators.
   2. Base-mounted, separately coupled, end-suction pumps.

1.2  SUBMITTALS

A. Product data including certified performance curves of selected models indicating selected pump’s operating point, weights (shipping, installed, and operating), furnished specialties, and accessories.

B. Shop drawings showing layout and connections for HVAC pumps. Include setting drawings with templates, and directions for installation of foundation bolts and other anchorages.

C. Wiring diagrams detailing wiring for power, signal, and control systems, differentiating between manufacturer-installed wiring and field-installed wiring.


1.3  QUALITY ASSURANCE

A. Hydraulic Institute Compliance: Design, manufacture, and install HVAC pumps in accordance with “Hydraulic Institute Standards.”

B. National Electrical Code Compliance: Provide components complying with NFPA 70 “National Electrical Code.”

C. UL Compliance: Provide HVAC pumps which are listed and labeled by UL, and comply with UL Standard 778 “Motor Operated Water Pumps.”

D. NEMA Compliance: Provide electric motors and components that are listed and labeled NEMA.

E. Single Source Responsibility: Obtain HVAC pumps from a single manufacturer.

F. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of HVAC pumps, and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions and profiles and efficiencies do not change the design concept or intended performance as judged by the Engineer.

PART 2 - PRODUCTS

2.1  MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the following:
   1. Inline Circulators:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett, ITT.
      c. Taco, Inc.
2. Base-Mounted, Separately-Coupled, End-Suction Pumps:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett, ITT.
   c. Taco, Inc.

2.2 PUMPS, GENERAL

A. Pumps and Circulators: Factory-assembled and factory-tested. Fabricate casings to allow removal and replacement of impellers without necessity of disconnecting piping. Type, sizes, and capacities shall be as indicated.

B. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles.

C. Motors: Conform to NEMA Standard MG-1, general purpose, continuous duty, Design B, except Design C where required for high starting torque; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal-overload protection, and grease-lubricated ball bearings. Select motors that are non-overloading within the full range of the pump performance curve.

D. Efficiency: “Energy Efficient” motors shall have a minimum efficiency as indicated in accordance with IEEE Standard 112, Test Method B. If efficiency is not specified, motor shall have a higher efficiency than the “average standard industry motors,” in accordance with IEEE Standard 112, Test Method B.

E. Motor Frame: NEMA Standard 48 or 54; use pump manufacturer’s standard.

F. Apply factory finish paint to assembled, tested units prior to shipping.

2.3 INLINE CIRCULATORS

A. General Description: Circulators shall be horizontal inline, centrifugal, separately-coupled, single-stage, bronze-fitted, radially split case design, with mechanical seals, and rated for 125 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with threaded companion flanges for piping connections smaller than 2-1/2 inches, and threaded gage tappings at inlet and outlet connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from Rolled Temper brass conforming to ASTM B 36, and keyed to shaft.

D. Pump Shaft and Sleeve: Steel shaft, with copper sleeve. Provide flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

E. Mechanical Seals: Carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

F. Pump Shaft Bearings: Oil-lubricated, bronze journal and thrust bearings.

G. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment.

H. Motors: Resiliently mounted to the pump casing.
2.4 VERTICAL INLINE PUMPS

A. General Description: Pumps shall be centrifugal, close-coupled, single-stage, bronze-fitted, radially split case design, with mechanical seals, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with threaded companion flanges for piping connections smaller than 2-1/2 inches, and threaded gage tappings at inlet and outlet connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, cast bronze, conforming to ASTM B 584, and keyed to shaft.

D. Wear Rings: Removable, bronze.

E. Pump Shaft and Sleeve: Ground and polished steel shaft, with bronze sleeve and integral thrust bearing. Provide flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

F. Seals: Mechanical Seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

G. Seals: Stuffing box having a minimum of 4 rings of graphite impregnated braided yarn with a bronze lantern ring between center 2 graphite rings and a bronze packing gland.

H. Motor: Direct-mounted to pump casing; with lifting and supporting lugs in top of motor enclosure.

2.5 BASE-MOUNTED, SEPARATELY-COUPLED, END-SUCTION PUMPS

A. General Description: Pumps shall be base-mounted, centrifugal, separately-coupled, end-suction, single-stage, bronze-fitted, radially split case design, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Casings Construction: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking cap screw.

D. Wear Rings: Replaceable, bronze.

E. Pump Shaft and Sleeve Bearings: Steel shaft, with bronze sleeve.

F. Seals: Mechanical seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket.

G. Seals: Stuffing box consisting of a minimum of 4 rings of graphite impregnated braided yarn with a bronze lantern ring between center 2 graphite rings, and a bronze packing gland.

H. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

I. Mounting Frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind
welds smooth prior to application of factory finish. Motor mounting holes for field-installed motors shall be field-drilled.

J. Motor: Secured to mounting frame with adjustable alignment on mounting frame.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of HVAC pumps.

B. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation.

C. Examine equipment foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 EQUIPMENT BASES

A. Construct concrete equipment pads as follows:

1. Form concrete pads using framing lumber with form release compounds. Chamfer top edge and corners of pad.

2. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves using manufacturer’s installation template.

3. Place concrete and allow to cure before installation of pumps. Use Portland Cement conforming to ASTM C150, 4,000 psi compressive strength, and normal weight aggregate.

3.3 INSTALLATION

A. General: Comply with the manufacturer’s written installation and alignment instructions.

B. Install pumps in locations and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

D. Suspend inline pumps using all thread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump independent from the piping system.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until the alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.

2. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check
the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.

3.4 ALIGNMENT
A. Align pump and motor shafts and piping connections after setting on foundations, after grout has been set and foundations bolts have been tightened, and after piping connections have been made.

1. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute “Centrifugal Pumps - Instructions for Installation, Operation and Maintenance.”

B. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

1. Alignment tolerances shall meet manufacturer’s recommendations.

3.5 CONNECTIONS
A. General: Install valves that are same size as the piping connecting the pump.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

C. Install a non-slam check valve and globe valve on the discharge side of inline pumps.

D. Install a triple-duty valve on the discharge side of base-mounted, end-suction pumps.

E. Install a gate valve and strainer on the suction side of inline pumps.

F. Install a pump suction diffuser and gate valve on the suction side of base-mounted, end-suction pumps.

G. Install flexible connectors on the suction and discharge side of each base-mounted pump. Install flexible connectors between the pump casing and the discharge valves, and upstream from the pump suction diffuser.

H. Install pressure gages on the suction and discharge of each pump at the integral pressure gage tappings provided.

I. Electrical wiring and connections are specified in other Sections.

J. Control wiring and connections are specified in other Sections.

3.6 FIELD QUALITY CONTROL
A. Check suction lines connections for tightness to avoid drawing air into the pump.

3.7 COMMISSIONING
A. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate oil-lubricated bearings.

2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and
thoroughly clean. Fill with new lubricant in accordance with the manufacturer’s recommendations.

3. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.

4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.

2. Open the valve in the cooling water supply to the bearings, where applicable.

3. Open the sealing liquid supply valve if the pump is so fitted.

4. Open the warm-up valve of a pump handling hot liquids if the pump is not normally kept at operating temperature.

5. Open the recirculating line valve if the pump should not be operated against dead shutoff.

6. Start the motor.

7. Open the discharge valve slowly.

8. Check the general mechanical operation of the pump and motor.

9. Close the recirculating line valve once there is sufficient flow through the pump to prevent overheating.

C. If the pump is to be started against a closed check valve with the discharge gate valve open, the steps are the same, except that the discharge gate valve is opened some time before the motor is started.

D. Detailed requirements for “Testing, Adjusting, and Balancing” are covered in other Sections.

END OF SECTION
SECTION 232300  REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air conditioning applications. This Section includes:

1. Pipes, tubing, fittings, and specialties.
2. Special duty valves.
3. Refrigerants.

B. Products installed but not furnished under this Section include pre-charged tubing, refrigerant specialties, and refrigerant accessories furnished as an integral part of or separately with packaged air conditioning equipment.

1.2 SUBMITTALS

A. Product data for the following products:

1. Each type valve specified.
2. Each type refrigerant piping specialty specified.

B. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment.

C. Brazer’s Certificates signed by Contractor certifying that brazers comply with requirements specified under “Quality Assurance” below.

D. Maintenance data for refrigerant valves and piping specialties, for inclusion in Operating and Maintenance Manual.

1.3 QUALITY ASSURANCE

A. Qualify brazing processes and brazing operators in accordance with ASME “Boiler and Pressure Vessel Code,” Section IX, “Welding and Brazing Qualifications.”

B. Regulatory Requirements: Comply with provisions of the following codes:

1. ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Refrigerant Valves and Specialties:
   a. Alco Controls Div, Emerson Electric.
   b. Danfoss Electronics, Inc.
   c. EATON Corporation, Control Div.
   d. Henry Valve Company.
   e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
   f. Sporlan Valve Company.
2.2 PIPE AND TUBING MATERIALS

A. Copper Tubing: ASTM B 280, Type ACR, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

B. Copper Tubing: ASTM B 88, Type L, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing.

2.3 FITTINGS

A. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

2.5 VALVES

A. General: Complete valve assembly shall be UL-listed and designed to conform to ARI 760.

B. Globe: 450 psig maximum operating pressure, 275°degF maximum operating temperature; cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections.

C. Check Valves - Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300° F maximum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

D. Check Valves - 7/8 inch and Larger: 450 psig maximum operating pressure, 300° F maximum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Valve shall be straight through or angle pattern, with solder-end connections.

E. Solenoid Valves: 250°F temperature rating, 400 psig working pressure; forged brass, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter, and 24 volt, 60 Hz. normally closed holding coil.

F. Evaporator Pressure Regulating Valves: pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gage tappings, 24 volts DC, 50/60 Hz, standard coil; and wrought copper fittings for solder end connections.

G. Thermal Expansion Valves: thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections; complete with sensing bulb, a distributor having a side connection for hot gas bypass line, and an external equalizer line.

H. Hot Gas Bypass Valve: adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading; and wrought copper fittings for solder end connections.
I. APR Control Device: Provide integral hot gas capacity control and humidity control device. Device provided by the equipment's manufacturer for field mounting, installation, piping and connections by that manufacturer's technician factory; match control device capacity to heat pump capacity. Provide all necessary components, piping, accessories and appurtenances including de-superheater and liquid injection valve. Hot gas capacity control device shall be integrally controlled as part of packaged heat pump.

2.6 REFRIGERANT PIPING SPECIALTIES

A. General: Complete refrigerant piping specialty assembly shall be UL-listed and designed to conform to ARI 760.

B. Strainers: 500 psig maximum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

C. Moisture/liquid Indicators: 500 psig maximum operation pressure, 200°F maximum operating temperature; forged brass body, with replaceable polished optical viewing window, and solder end connections.

D. Filter-driers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

   1. High capacity desiccant sieves to provide micronic filtration and extra drying capacity.

E. Suction Line Filter-Drier: 350 psig maximum operation pressure, 225°F maximum operating temperature; steel shell, and wrought copper fittings for solder end connections. Permanent filter element shall be molded felt core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

F. Suction Line Filters: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter core kit, including gaskets, as follows:

G. Flanged Unions: 400 psig maximum working pressure, 330°F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions shall be forged steel, and for 2-1/8 inch through 3-1/8 inch shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory-applied rust-resistant coating.

H. Flexible Connectors: 500 psig maximum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.2 PIPE APPLICATIONS

A. Use Type L, or Type ACR drawn copper tubing with wrought copper fittings and brazed joints above
ground, within building. Use Type K, annealed temper copper tubing for 2 inch and smaller without joints, below ground and within slabs. Mechanical fittings (crimp or flair) are not permitted.

1. Install annealed temper tubing in pipe duct. Vent pipe duct to the outside.

B. If other than Type ACR tubing is used, clean and protect inside of tubing as specified in Article “CLEANING” below.

3.3 PIPING INSTALLATIONS


B. Install piping in as short and direct arrangement as possible to minimize pressure drop.

C. Install piping for minimum number of joints using as few elbows and other fitting as possible.

D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

F. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

G. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

H. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

I. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2” per 10 feet downward slope away from the compressor.

2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

4. Liquid lines may be install level.

J. Use fittings for all changes in direction and all branch connections.

K. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

L. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
M. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

N. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

O. Locate groups of piping parallel to each other, spaced to permit applying insulation and servicing of valves.

P. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

Q. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 7 for special sealers and materials.

R. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

S. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

T. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.

1. Install moisture/liquid indicators in lines larger than 2-1/8 inch OD, using a bypass line.

U. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

V. Install flexible connectors at the inlet and discharge connection of compressors.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors are specified in other Sections. Conform to the table below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe rollers complete supports for multiple horizontal runs, 20 feet or longer supported by a trapeze.

4. Spring hangers to support vertical runs.
C. Install hangers with the following minimum rod sizes and maximum spacing:

<table>
<thead>
<tr>
<th>Nom. Pipe Size</th>
<th>Max. Span-Ft</th>
<th>Min. Rod Size - Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/2</td>
<td>9</td>
<td>3/8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>1/2</td>
</tr>
<tr>
<td>3-1/2</td>
<td>13</td>
<td>1/2</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>5/8</td>
</tr>
</tbody>
</table>

D. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual.”

1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

2. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats, and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do not apply heat near the bulb of the expansion valve.

B. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.

C. Heat joints using oxy-acetylene torch. Heat to proper and uniform brazing temperature.

3.6 VALVE INSTALLATIONS

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer’s instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

C. Install a full sized, 3-valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at the top.

1. Electrical wiring for solenoid valves is specified in Division 26. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.

2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.

3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.
4. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.7 EQUIPMENT CONNECTIONS

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

B. Install piping adjacent to machine to allow servicing and maintenance.

3.8 FIELD QUALITY CONTROL

A. Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI.

B. Repair leaking joints using new materials, and retest for leaks.

3.9 CLEANING

A. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician’s tape.

2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.

3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.

4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.10 ADJUSTING AND CLEANING

A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Clean and inspect refrigerant piping systems.

C. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.11 COMMISSIONING

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.

2. Evacuate refrigerant system with vacuum pump; until temperature of 35°F is indicated on vacuum dehydration indicator.

3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.

5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.

6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train Owner’s maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

C. Review data in Operating and Maintenance Manuals.

D. Schedule training with Owner through the Architect, with at least 7 days’ advance notice.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This section includes refrigerant leak detectors.

1.2 SUBMITTALS

A. Product data.

B. Manufacturer’s descriptive literature, operating instructions, and maintenance and repair data.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Equipment room refrigerant leak monitoring: Equal to a Haloguard Model 173-112 ABDE manufactured by Thermal Gas Systems. Include the following features:
   1. Enclosure shall UL 94-V0 rated ABS plastic
   2. 5 pin DIN connectors for easy extendibility of sensor cable
   3. 0 to 200 PPM calibrated for the chiller refrigerant being used.
   4. 2 amp dry contact “alarm” relay
   5. 2 amp dry contact “fault” relay
   6. 0 to 10 VDC analog output
   7. 90 dB audible alarm
   8. Battery back-up
   9. 115 VAC Class 2 power supply
   10. Clear plastic lockable enclosure

B. Sampling sensors: Provide manufacturer’s sampling elements/sensors at sensing locations required for the refrigerant being monitored and in quantity/locations to provide complete coverage of the space.

C. Conduit: rigid galvanized steel.

D. Control wire: supplied by leak detector manufacturer.

E. Calibration Equipment and Options: Provide manufacturer’s calibration kit with all required accessories and sample/test gases including, but not limited to, the following.
   1. HFC-134 Span Gas
   2. Zero Gas, 99.9% Nitrogen
   3. Audible Horn
   4. Zero Gas Scrubber
   5. Span Gas Scrubber
PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Drawings indicate general arrangement of refrigerant leak monitor.

B. Install wiring and conduit to allow replacement, servicing, and maintenance.

C. Install electrical connections to power supply, system components, and interlocks to chillers and exhaust fan system.

D. Electrical Connections: Power wiring and disconnect switches are specified in Division 26.

E. Grounding: Connect unit components to ground according to the National Electrical Code.

3.2 INSTALLATION

A. Install refrigerant leak detector according to manufacturer’s instructions.

B. Refrigerant leak detection system shall be placed just outside the doorway of the monitored area so that personnel may check the status of the instrument before entering the monitored area.

C. Sampling lines with sensors shall be located in all required locations for complete coverage of the space being monitored per manufacturer’s recommendations. Such areas may include:

1. Chiller(s).
2. Valves and fittings.
3. Refrigerant storage areas.
4. Pits, stairwells or trenches.

3.3 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Provide services of a factory-authorized service representative to supervise and inspect the installation of refrigerant leak detector monitoring system. Include equipment, alarms, interlocks with other equipment, and electrical connections. Report results in writing.

B. Comply with operating instructions and procedures including the following inspections and tests to demonstrate compliance with requirements:

1. Check mechanical items.
2. Inspect and check mountings for adequate anchoring to substrate.
3. Check electrical systems.
4. Check enclosure integrity.
5. Functional (predischarge) test.
8. Control-panel primary power source.
9. Perform “Puff” test using refrigerant R-134A.

C. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.

3.4 COMMISSIONING

A. Provide service of factory-authorized service representative to provide start-up service.

3.5 DEMONSTRATION

A. Provide services of factory-authorized service representative to demonstrate and train Owner’s maintenance personnel as specified below.

B. Procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventive maintenance.

C. Review data in Operating and Maintenance Manuals.

D. Schedule training with at least a 7-day advance notice.

END OF SECTION
SECTION 232500 - CONDENSER WATER TREATMENT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Extent of condenser water treatment system work required by this section is indicated on drawings and schedules and by requirements of this section, and includes necessary equipment, chemicals, and service to inhibit development of scale, corrosion, and biological growth in the following systems:

1. Condenser water system.

B. Service Period: Provide chemicals and service program for period of one year from start-up date of condensing equipment, including the following:

1. Initial water analysis and recommendations.
2. Systems start-up assistance.
3. Training of operating personnel.
4. Periodic field service and consultation.
5. Customer report charts and log sheets.
6. Laboratory technical assistance.

C. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on water treatment equipment. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

2. Interlock wiring specified as factory-installed is work of this section.

D. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels.

1.2 QUALITY ASSURANCE

A. Supplier: Water treatment chemical and service supplier who has been active in field of industrial water treatment for not less than 5 years, and who has full-time service personnel located within trading area of job site.

B. Codes and Standards:

1. UL and NEMA Compliance: Provide electrical components required as part of condenser water treatment equipment, which are UL-listed and labeled and comply with NEMA Standards.

2. NEC Compliance: Comply with National Electrical Code as applicable to installation, electrical connections, and ancillary electrical components of condenser water treatment equipment.

3. Chemical Standards: Provide only chemical products which are acceptable under state and local pollution control regulations.
1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s technical product data, including rated capacities of selected equipment clearly indicated, water pressure drops, weights, installation and start-up instructions, and furnished specialties and accessories.

B. Shop Drawings: Submit manufacturer’s assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer’s electrical requirements for power supply wiring to water treatment equipment. Submit manufacturer’s ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data: Submit maintenance data and parts list for each item of equipment, control, and accessory; including “trouble-shooting” maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

1.4 EXTENDED MAINTENANCE SERVICES

A. Agreement to Maintain: Prior to time of final acceptance, submit 4 copies of “Agreement for Continued Service and Maintenance” for condenser water treatment system, for Owner’s possible acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing, and including replacement of materials and equipment, for one-year period with option for renewal of Agreement by Owner.

1.5 WARRANTY

A. Manufacturer’s Warranty: One year warranty for 2 years for electronics and 1 year for mechanical parts from date of installation. Warranty to commence after commissioning and complete system acceptance.

PART 2 - PRODUCTS

2.1 PERFORMANCE OF EQUIPMENT

A. General: Provide system sized and equipped to treat raw water available at project site to maintain the following condenser water characteristics (tested values for condenser operation):
   1. Hardness: 0.00.
   2. Iron: 0.00.
   3. Total Alkalinity: 1026 or less.
   4. Silica: 120 or less.
   5. Total Algae: 0.00 growth.
   6. pH: 10.5 or above.

2.2 MATERIALS AND EQUIPMENT

A. General: Except as otherwise indicated, provide condenser water treatment system manufacturer’s standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.
B. Chemical Treatment Controller: Provide the following type of control:

1. Water-flow meter.
2. Conductivity.
3. pH.

C. Chemical Feeder Metering Pump: Provide the following type:
1. Positive displacement diaphragm pump with integral anti-siphon valve.

D. Chemical Solution Reservoir: Provide chemical resistant reservoir fabricated from either high density opaque polyethylene or metal; with factory-installed internal floating suction assembly.

E. Condenser Water Sample Test Kit: Furnish kit including carrying case and spare reagents, recommended by condenser water treatment system manufacturer for determining water hardness and water characteristics.

F. Chemicals, Condenser Water Treatment: Furnish chemicals recommended by condenser water treatment system manufacturer for treating water to meet specified water quality.

1. Ascertain from condenser water piping system Installer, what materials are used for condenser pump seals. Provide only chemicals that are compatible with these materials.

G. Available Manufacturers: Subject to compliance with requirements, manufacturers offering condenser water treatment system which may be incorporated in the work include, but are not limited to, the following:

1. Betz Laboratories, Inc.
2. Calgon Corporation.
3. Culligan USA; Industrial Div.
4. Dearborn Chemical, Chemed Corp.
5. Drew Chemical Corp.
6. Mogul; Div of the Dexter Corp.
7. Nalco Chemical Co.
8. Walchem, Iwaki America, Inc.

PART 3 - EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which condenser water treatment systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF CONDENSER WATER TREATMENT SYSTEM

A. General: Install condenser water treatment system in accordance with manufacturer’s written instructions.

B. Coordinate with other work (plumbing drain piping) as necessary to interface components of condenser water treatment system properly with condenser cooling water system.

C. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s wiring diagram submittal to Electrical Installer.
1. Verify that electrical wiring installation is in accordance with manufacturer’s submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

D. Install pressure gages, valves, and controls furnished by manufacturer, in accordance with manufacturer’s instructions.

3.3 PRECLEANING

A. General: Flush condensers using precleaning chemicals designed to remove construction deposits such as pipe dope, oils, loose mill scale, and other extraneous materials. Add recommended dosages and recirculate for 6 to 8 hours. Drain and flush until total alkalinity of rinse water is equal to make-up water. Refill with treated clean water.

3.4 START-UP

A. Start-Up Procedures: During condenser cooling water system start-up, operate condenser water treatment system (after charging with specified chemicals) to maintain required steady-state characteristics of cooling water.

3.5 TESTING

A. Sample condenser cooling water at one-week intervals after condenser start-up for period of 4 weeks and prepare certified test report for each required water performance characteristic. Comply with the following standards, where applicable:

2. ASTM D 1067 - Test Methods for Acidity or Alkalinity of Water.

3.6 TRAINING OF OWNER’S PERSONNEL

A. Provide services of supplier’s representative for one-half day to instruct Owner’s personnel in operation, maintenance, and testing procedures of condenser water treatment system.

END OF SECTION
SECTION 232923  VARIABLE FREQUENCY DRIVE FOR HVAC MOTOR CONTROL

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. Furnish all labor, materials, equipment, and services necessary for, and incidental to, the installation of Variable Frequency Drive for Motor Control as shown on the drawings, and/or as specified herein.

B. This specification shall cover a complete variable frequency motor drive consisting of a pulse width modulated inverter for use on standard NEMA Design B induction or synchronous motors.

C. The adjustable frequency system shall be rated for continuous duty.

1.2 QUALITY ASSURANCE

A. The Variable Frequency Drive shall meet the following requirements:

1. Underwriters Laboratories.
2. NEMA.

B. Manufacturer’s warranty including all parts, labor and travel to replace defective materials and workmanship for a period of two (2) years after acceptance.

1.3 SUBMITTALS

A. Product Data: Manufacturer’s descriptive literature for each type of device or equipment to be used on the project, indicating compliance with specified requirements.

B. Shop Drawings: Indicating drive designation, manufacturer, type, ratings, accessories and features for each variable speed drive. Also provide complete schematic wiring and field wiring diagrams.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. Manufacturer shall be regularly engaged in the design and production of AC variable frequency drives (VFD’s) for a minimum of 10 years. Private labeled products are not acceptable to ensure parts availability and future support.

2.2 GENERAL TECHNOLOGY

A. The VFD shall utilize a full wave diode bridge rectifier to convert 3Ø, 60 Hz utility power to a fixed DC voltage. SCR’s and half wave rectifiers are not acceptable.

B. The DC bus shall be filtered by a series of capacitors to provide smooth DC voltage.

C. Intelligent Power Modules shall be utilized to invert the fixed DC voltage to a variable voltage and frequency for stepless motor speed control from 0% to 100% of the motor’s nameplate base speed. Other types of semiconductors that do not improve reliability by integrating drive protection circulatory into a modular design are not acceptable.
2.3 ENVIRONMENTAL RATINGS

A. Storage temperature  -20°C to 70°C
B. Ambient operating temperature  0°C to 40°C
C. Non-condensing Humidity  95%
D. Altitude without derating  3,300 ft. (1000 m)

2.4 ELECTRICAL SPECIFICATION

A. 200/240, 400/480, 480/590V Tolerance  +10%/-15
B. AC line frequency tolerance  48 Hz to 62 Hz
C. Frequency stability  +/- 0.00006%/°C
D. Service Factor  1.0
E. Waveform  Sine coded PWM
F. Carrier Frequency  2.5, 8, 10, 12, 14 kHz
G. Drives shall operate at a minimum carrier frequency of 8 kHz. Drives through 150Hp that cannot continuously produce full nameplate ratings at 8 kHz are not acceptable.

2.5 STANDARD DESIGN FEATURES

A. The VFD shall provide full protection under the following conditions:
   1. Over temperature
   2. Over and under voltage
   3. Phase to Phase short circuit
   4. Ground Fault
   5. Motor Overload

B. The door mounted interface shall display a minimum of 32 characters in English. Simultaneous display of status, set speed, load, rotational direction and speed reference source is required.

C. The drive shall have the following digital metering capabilities:
   1. Speed: Hz, RPM, %, /S, /M, /H, #/S, #/M or #/H
   2. Ammeter: Amps or % Load
   3. kWh meter
   4. Elapsed time meter
   5. Manufacturers deviating from this standard shall provide analog metering devices.

D. The VFD shall be capable of automatically restarting after a power loss or fault condition. Prior to starting, the drive display shall indicate “Start Pending.” Drives without this safety feature shall provide a pilot device to indicate the drive is about to auto-restart.
E. Two (2) selectable critical frequency rejection points with a minimum bandwidth of 10 Hz.

F. Programmable input signal followers:

1. Analog 0 – 10 V DC
2. Analog 4 – 20 mA DC
3. Analog 20 – 4 mA DC
4. Three (3) preset speeds
5. Keypad

G. An analog output proportional to speed or load shall be user definable for 0 – 10 V DC or 4 – 20 mA DC.

H. RS-232 terminals to allow for remote control from the building automation system (BAS). Software shall be provided to allow for remote monitoring and programming (including start/stop and speed control) of the VFD from the BAS computer.

I. User programmable password security to restrict parameter access by unauthorized personnel.

J. Two (2) form “C” relays related for 2 amps at 28V DC and 120V AC shall be provided. Each relay shall be configurable to change state under any one of the following conditions; Run, Fault, Fault Lockout, At Speed, Current Limit, Follower Present or Auto Speed Mode. In addition, an open collector output (24V DC) shall be provided to power a relay or pilot light under any one of the listed conditions.

K. Comprehensive diagnostic circuitry shall log 8 protective shutdowns into nonvolatile memory. Each event is logged with the elapsed time, condition and system operating status.

L. The VFD shall ride through a 0.4 second power dip.

M. The drive shall provide PID setpoint control to maintain a system variable such as pressure or temperature.

N. Three phase line reactors shall be provided on 200/240V and 400/480V units 25HP and above. Line reactors shall be provided on 480/590V units 5HP and above. DC bus chokes are not acceptable.

O. Provide with integral automatic switching frequency (1.5 kHz to 10 kHz) and integral harmonic filters for high quality harmonic current produced by the drive for motor noise reduction.

2.6 BYPASS SPECIFICATION

A. A padlockable door interlocked disconnect shall be provide to positively interrupt incoming AC power.

B. Separate fusing shall be provided for the drive and bypass operation.

C. Two electrically and mechanically interlocked contactors shall be provided to connect the motor to either the VFD output or the AC line. A third contactor shall isolate the VFD input.

D. A Hand-Off-Auto switch will set the control scheme of the drive. In Hand, the drive will start and follow a remote speed reference or a keypad speed command. In Auto, the drive will start via a remote contact closure and follow either a keypad speed command or a remote speed reference. In Off, the drive will not start.
E. A Drive Mode-Off/Reset-Bypass Mode switch shall switch the motor between VFD control and Bypass control.

F. A Drive Test-Off-Drive Normal switch shall provide control of the VFD input contactor. The VFD input contactor will be energized while in bypass mode with the switch in the Drive Test position. In Off, the input contactor is de-energized. In Drive Normal, the input contactor is energized while in drive mode.

G. Four pilot lights shall indicate “Power”, “Bypass Mode”, “Drive Mode” and “Safety Circuit Fault.”

H. A control transformer shall provide 120V AC for the control logic.

I. Upon a fault condition the drive shall automatically attempt to restart up to 5 times. If the fault condition remains after the fifth attempt control will automatically transfer to bypass mode.

J. The drive shall be removable from the bypass module without losing the ability to control the motor in bypass mode.

2.7 QUALITY ASSURANCE

A. The VFD/Bypass package shall be UL listed and CSA approved.

B. Printed circuit boards shall be burned in for a minimum of 100 hours on computer automated test equipment.

C. Competed VFD’s shall be burned in under a heat load stress test for a minimum of 8 hours.

D. The manufacturer’s warranty shall cover the VFD and all components for two years from shipment or eighteen months from start-up whichever occurs first.

PART 3 - EXECUTION

3.1 GENERAL

A. Install drives in strict accordance with manufacturer’s published recommendations. Make all connections to motors and drives complete and leave all equipment in operating order. Verify nameplate ratings of motors installed and report any discrepancies.

3.2 OVERCURRENT AND OVERLOAD PROTECTION

A. Proper fusing and overload ratings to be determined by the drive manufacturer.

3.3 START-UP AND TESTING

A. Provide the services of manufacturer’s trained technician to start-up drives and test for proper installation and operation. Technician to also provide at least (8) hours of instruction for the Owner’s staff in the operation, testing and maintenance of equipment.

3.4 ADJUSTMENTS

A. Adjust acceleration, deceleration, minimum current limit, and any other adjustments as recommended by the drive manufacturer to compliment load characteristics and achieve optimum performance.
3.5 WARNING LABELS

A. Install in prominent location at each drive, labels describing any and all precautions or procedures which are necessary during operation or maintenance to protect the drive from any possible damage.

3.6 POWER AND CONTROL WIRING - UNIT MANUFACTURER

A. Shall be furnished and installed in accordance with all applicable codes and specification sections attached.

END OF SECTION
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes rectangular and round metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2490 Pa).

1.2 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F or W/m x K at the temperature differences specified. Values are expressed as Btu or W.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select and size air-moving and distribution equipment and other components of air system. Changes to layout or configuration of duct system must be specifically approved in writing by Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

A. Product Data: For duct liner and sealing materials.

B. Shop Drawings: Show details of the following:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Duct layout indicating pressure classifications and sizes on plans.
   3. Fittings.
   4. Reinforcement and spacing.
   5. Seam and joint construction.
   6. Penetrations through fire-rated and other partitions.
   7. Terminal unit, coil, and humidifier installations.
   8. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and duct attachment.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
   1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.

3. Ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.

4. Coordination with ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.

D. Welding Certificates: Copies of certificates indicating welding procedures and personnel comply with requirements in “Quality Assurance” Article.

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

F. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.5 QUALITY ASSURANCE


C. Comply with NFPA 90B, “Installation of Warm Air Heating and Air Conditioning Systems,” unless otherwise indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle sealant and firestopping materials according to manufacturer’s written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Aluminum Sheets: ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14, sheet form with standard, one-side bright finish for ducts exposed to view and with mill finish for concealed ducts.

C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
D. **Tie Rods:** Galvanized steel, 1/4-inch (6-mm) minimum diameter for 36-inch (900-mm) length or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

### 2.2 DUCT LINER

#### A. General: Comply with NFPA 90A or NFPA 90B and NAIMA’s “Fibrous Glass Duct Liner Standard.”

#### B. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.

1. **Thickness:** 1-1/2 inches (38 mm).
2. **Thermal Conductivity (k-Value):** 0.26 at 75E F (0.037 at 24E C) mean temperature.
3. **Fire-Hazard Classification:** Maximum flame-spread rating of 25 and smoke-developed rating of 50, when tested according to ASTM C 411.
4. **Liner Adhesive:** Comply with NFPA 90A or NFPA 90B and ASTM C 916.
5. **Mechanical Fasteners:** Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
   - **Tensile Strength:** Indefinitely sustain a 50-lb- (23-kg-) tensile, dead-load test perpendicular to duct wall.
   - **Fastener Pin Length:** As required for thickness of insulation and without projecting more than 1/8 inch (3 mm) into airstream.
   - **Adhesive for Attaching Mechanical Fasteners:** Comply with fire-hazard classification of duct liner system.

### 2.3 SEALANT MATERIALS

#### A. Joint and Seam Sealants, General: The term “sealant” is limited to materials of adhesive or mastic nature.

1. **Joint and Seam Sealant:** One-part, nonsag, solvent-release-curing, polymerized butyl sealant, formulated with a minimum of 66 percent solids.
2. **Flanged Joint Mastics:** One-part, acid-curing, silicone, elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

### 2.4 HANGERS AND SUPPORTS

#### A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
2. **Exception:** Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
B. Hanger Materials: Galvanized, sheet steel or round, threaded steel rod.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rod or galvanized rods with threads painted after installation.
   2. Straps and Rod Sizes: Comply with SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible” for sheet steel width and thickness and for steel rod diameters.
C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
   2. Supports for Aluminum Ducts: Aluminum support materials, unless materials are electrolytically separated from ductwork.

2.5 RECTANGULAR DUCT FABRICATION
A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible.” Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
   2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
B. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:
   1. Supply Ducts: 3-inch wg (750 Pa).
   2. Return Ducts: 2-inch wg (500 Pa), negative pressure.
   3. Exhaust Ducts: 2-inch wg (500 Pa), negative pressure.
C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area, unless ducts are lined.

2.6 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS
A. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness are prohibited.
B. Apply adhesive to liner facing in direction of airflow not receiving metal nosing.
C. Butt transverse joints without gaps and coat joint with adhesive.
D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
E. Do not apply liners in rectangular ducts with longitudinal joints, except at corners of ducts, unless
duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).

G. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely around perimeter; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or “Z” profile or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Fan discharge.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts.

I. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire-damper sleeve.

2.7 ROUND DUCT FABRICATION

A. Round Ducts: Fabricate supply ducts of galvanized steel according to SMACNA’s “HVAC Duct Construction Standards—Metal and Flexible.”

2.8 ROUND SUPPLY AND EXHAUST FITTING FABRICATION

A. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA’s “HVAC Duct Construction Standards—Metal and Flexible,” with metal thicknesses specified for longitudinal seam straight duct.

B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

C. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate bend radius of die-formed, gored, and pleated elbows one and one-half times elbow diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA’s “HVAC Duct Construction Standards—Metal and Flexible,” unless otherwise indicated.

2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):

   a. Ducts 3 to 26 Inches (75 to 660 mm) in Diameter: 0.028 inch (0.7 mm).
   b. Ducts 27 to 36 Inches (685 to 915 mm) in Diameter: 0.034 inch (0.85 mm).
   c. Ducts 37 to 50 Inches (940 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
d. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
e. Ducts 62 to 84 Inches (1575 to 2130 mm) in Diameter: 0.064 inch (1.6 mm).

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg (500 to 2490 Pa):
   a. Ducts 3 to 14 Inches (75 to 355 mm) in Diameter: 0.028 inch (0.7 mm).
b. Ducts 15 to 26 Inches (380 to 660 mm) in Diameter: 0.034 inch (0.85 mm).
c. Ducts 27 to 50 Inches (685 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
d. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
e. Ducts 62 to 60 Inches (1320 to 1525 mm) in Diameter: 0.064 inch (1.6 mm).

4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal seam flat-oval duct.

5. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material-handling classes A and B; and only where space restrictions do not permit using 1.5 bend radius elbows. Fabricate with single-thickness turning vanes.

6. Round Elbows, 8 Inches (200 mm) and Smaller: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.

7. Round Elbows, 9 through 14 Inches (225 through 355 mm): Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees, unless space restrictions require a mitered elbow. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.

8. Round Elbows, Larger Than 14 Inches (355 mm), and All Flat-Oval Elbows: Fabricate gored elbows, unless space restrictions require a mitered elbow.

9. Die-Formed Elbows for Sizes through 8 Inches (200 mm) and All Pressures: 0.040 inch (1.0 mm) thick with two-piece welded construction.

10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.

11. Pleated Elbows for Sizes through 14 Inches (355 mm) and Pressures through 10-Inch wg (2490 Pa): 0.022 inch (0.55 mm).

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

A. Drawings indicate general arrangement of ducts, fittings, and accessories. Provide all required fittings, accessories and ancillaries as required for a complete system as determined by the Engineer.

B. Construct and install each duct system for the specific duct pressure classification indicated.
C. Install round and flat-oval ducts in lengths not less than 12 feet (3.7 m), unless interrupted by fittings.

D. Install ducts with fewest possible joints.

E. Install fabricated fittings for changes in directions, changes in size and shape, and connections.

F. Install couplings tight to duct wall surface with a minimum of projections into duct.

G. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

L. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches (38 mm).

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Refer to other sections for fire and smoke damper specifications as well as fire stopping specifications.

3.2 SEAM AND JOINT SEALING

A. General: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible.”

B. Pressure Classification Less Than 2-Inch wg (500 Pa): Transverse joints.

C. Seal externally insulated ducts before insulation installation.

3.3 HANGING AND SUPPORTING

A. Install rigid round and rectangular, flat-oval metal duct with support systems indicated in SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible.”

B. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

C. Support vertical ducts at a maximum interval of 16 feet (5 m) and at each floor.
D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

E. Install concrete inserts before placing concrete.

F. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3.4 CONNECTIONS

A. Connect equipment with flexible connectors according to other Sections.

B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible.”

3.5 FIELD QUALITY CONTROL

A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.

B. Conduct tests, in presence of Architect, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days’ advance notice for testing.

C. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (500 Pa) (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg (500 to 2490 Pa).

D. Remake leaking joints and retest until leakage is less than maximum allowable.

E. Leakage Test: Perform tests according to SMACNA’s “HVAC Air Duct Leakage Test Manual.”

3.6 ADJUSTING

A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.

B. Detailed procedures for Testing, Adjusting, and Balancing are specified in other Sections.

3.7 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.

END OF SECTION
SECTION 233300 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Backdraft dampers.
   3. Fire dampers.
   4. Duct silencers.
   5. Turning vanes.
   6. Duct-mounted access doors and panels.
   7. Flexible ducts.
   8. Flexible connectors.
   9. Duct accessory hardware.

1.2 SUBMITTALS

A. Product Data: For the following:
   1. Backdraft dampers.
   3. Fire dampers.
   4. Duct silencers.
   5. Duct-mounted access doors and panels.
   6. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:
   2. Fire- and smoke-damper installations, including sleeves and duct-mounted access doors and panels.

C. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA standards:
   2. NFPA 90B, “Installation of Warm Air Heating and Air Conditioning Systems.”

1.4 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.
PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Aluminum Sheets: ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish for ducts exposed to view and mill finish for concealed ducts.


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 (6-mm) minimum diameter for 36-inch (900-mm) length or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 BACKDRAFT DAMPERS

A. Description: Suitable for horizontal or vertical installations.

B. Frame: 0.052-inch (1.3-mm) thick, galvanized, sheet steel, with welded corners and mounting flange.

C. Blades: 0.025-inch (0.6-mm) thick, roll-formed aluminum.

D. Blade Seals: Neoprene.

E. Blade Axles: Galvanized steel.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

2.3 MANUAL-VOLUME DAMPERS

A. General: Factory fabricated with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classifications of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

B. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.

2. Roll-Formed Steel Blades: 0.064-inch (1.62-mm-) thick, galvanized, sheet steel.


5. Tie Bars and Brackets: Galvanized steel.

C. Jackshaft: 1-inch- (25-mm-) diameter, galvanized steel pipe rotating within a pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper of a multiple-damper assembly.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 FIRE DAMPERS

A. General: Labeled to UL 555.

B. Fire Rating: One and one-half and three hours.

C. Frame: SMACNA Type B with blades out of airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

D. Mounting Sleeve: Factory- or field-installed galvanized, sheet steel.

1. Minimum Thickness: 0.052 inch (1.3 mm) or 0.138 inch (3.5 mm) thick as indicated, and length to suit application.

2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized, sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized steel blade connectors.

G. Horizontal Dampers: Include a blade lock and stainless-steel negator closure spring.

H. Fusible Link: Replaceable, 165 or 212°F (74 or 100°C) rated as indicated.

2.5 DUCT SILENCERS

A. General: Factory-fabricated and -tested, round or rectangular silencer with performance characteristics and physical requirements as indicated.

B. Fire Performance: Adhesives, sealers, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame spread and 50 for smoke developed when tested according to ASTM E 84.

C. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- (0.85-mm-) thick, solid sheet metal for outer casing and 0.022-inch- (0.55-mm-) thick, perforated sheet metal for inner casing.

D. Sheet Metal Perforations: 1/8-inch (3-mm) diameter for inner casing and baffle sheet metal.
E. Nonfibrous Acoustic-Fill Material: Moisture-proof nonfibrous material.

F. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
   1. Do not use nuts, bolts, and sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. Reinforcement: Cross or trapeze angles for rigid suspension.

G. Source Quality Control: Perform the following factory tests:
   1. Acoustic Performance: Test according to ASTM E 477, with airflow in both directions through silencer.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels, for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with an airflow of at least 2000-fpm (10-m/s) face velocity.
   3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

2.6 TURNING VANES
A. Manufactured Turning Vanes: Fabricate of 1-1/2-inch- (38-mm-) wide, curved blades set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into side strips suitable for mounting in ducts.

2.7 DUCT-MOUNTED ACCESS DOORS AND PANELS
A. General: Fabricate doors and panels airtight and suitable for duct pressure class.
B. Frame: Galvanized, sheet steel, with bend-over tabs and foam gaskets.
C. Door: Double-wall, galvanized, sheet metal construction with insulation fill and thickness, and number of hinges and locks as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
E. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.8 FLEXIBLE CONNECTORS
A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
   1. Standard Metal-Edged Connectors: Factory fabricated with a strip of fabric 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized, sheet steel or 0.032-inch (0.8-mm) aluminum sheets. Select metal compatible with connected ducts.
B. Extra-Wide Metal-Edged Connectors: Factory fabricated with a strip of fabric 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized, sheet steel or 0.032-inch (0.8-mm) aluminum sheets. Select metal compatible with connected ducts.

   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp, and 360 lbf/inch (63 N/mm) in the filling.

D. Conventional, Outdoor System Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber, weatherproof coating resistant to the sun’s ultraviolet rays and ozone environment.
   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp, and 440 lbf/inch (77 N/mm) in the filling.

2.9 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 1.

B. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch- (38-mm-) thick, glass-fiber insulation around a continuous inner liner.
   1. Reinforcement: Steel-wire helix encapsulated in inner liner.
   3. Inner Liner: Polyethylene film.

C. Pressure Rating: 6-inch wg (1500 Pa) positive, 1/2-inch wg (125 Pa) negative.

2.10 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 length to suit duct insulation thickness.

B. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 to 18 inches (75 to 450 mm) to suit duct size.

C. 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 shown in SMACNA’s “HVAC Duct Construction Standards--Metal and Flexible” for metal ducts and NAIMA’s “Fibrous Glass Duct Construction Standards” for fibrous-glass ducts.
B. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

D. Install fire dampers according to manufacturer’s UL-approved written instructions.
   1. Install fusible links in fire dampers.

E. Install duct access panels for access to both sides of duct coils. Install duct access panels downstream from volume dampers, fire dampers, turning vanes, and equipment.
   1. Install duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining accessories and terminal units.
   2. Install access panels on side of duct where adequate clearance is available.

F. Label access doors according to other Sections.

G. Flexible ducts shall be a maximum length of 4 feet. Provide a rigid elbow at connection to ceiling mounted registers, diffusers, and grilles. Flexible ducts shall only be used on supply air ductwork systems. Flexible ducts shall not be used on return and exhaust air systems.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire dampers for proper action.

C. Final positioning of manual-volume dampers is specified in other Sections.

END OF SECTION
SECTION 233301 – DUCTWORK CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides the requirements for HVAC system cleaning and refurbishment, and indoor air quality assurance both in terms of a general scope of work and contractor qualifications and experience, execution, products, and submittals.

1.2 SYSTEM DESCRIPTION

A. The duct systems covered under this specification consist of ALL supply, return and exhaust air ductwork serving the facility and that is indicated to remain in service following the renovation work indicated on these contract documents.

B. The bidders are encouraged to attend the pre-bid, site visit conference prior to submission of a bid proposal, to compare site conditions with drawings and/or specifications and to satisfy themselves of conditions existing at the site and all other matters that may be incidental to the work performed under this contract. No allowance will be made to the successful contractor by reason of any error on his/her part due to neglect to comply with the requirements of this paragraph. No extra charge will be allowed for work caused by unfamiliarity with the work area.

1.3 SUBMITTALS

A. Product, qualifications and procedural data: Include the following:

1. Current NADCA membership certificate

2. Current Air System Cleaning Specialist (ASCS) Certificates of three (3) currently employed personnel

3. Description of cleaning methods, systems, and procedures – and the effects on the system, include: requirements for access and the impact of disruption to the occupied space, duct leakage, and structural integrity of the ductwork. Include cut sheets of agitation equipment that can clean up to 50 feet in each direction.

4. MSDS sheets on all sanitizers, coatings, solvents, cleaners and disinfectants to be used on the Project.

5. Cut sheets on any equipment or materials replacing the existing during the remediation process.

6. Air Testing Qualifications and Experience, and description of air quality monitoring instrumentation and current calibration certificates

7. Qualifications and experience summary (contractor), to include references for similar size and scope projects.

1.4 QUALITY ASSURANCE

A. Contractor Requirements: Firms that are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination. The HVAC System Cleaning Contractor shall have the following qualifications:
1. Shall be a current member in good standings of the National Air Duct Cleaners Association (NADCA).

2. Shall have a minimum of three (3) Air System Specialists (ASCS) certified by NADCA on a full time basis on staff.

3. Shall have at least one (1) certified NADCA Ventilation System Mold Remediator (VSMR) on staff.

4. Shall have at least 5 (five) years of experience in air systems and ductwork remediation in commercial buildings of similar type.

5. Shall produce a reference list to the Owner and Project Engineer of projects successfully completed of a similar size and scope.

B. Ductwork shall be cleaned in compliance with HVAC system cleaning requirements in the latest edition of the following standards:

1. Assessment, Cleaning and Restoration of HVAC Systems (ACR 2006); National Air Duct Cleaners Association (NADCA).

2. Plans and Specifications which exceed the requirements in any of the referenced standards.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Cleaning Agent:

1. An E.P.A. registered sanitizer that is specific for application inside HVAC / ductwork systems, such as "BBJ" microbiocide as manufactured by BBJ Environmental Solutions, Inc. Application shall be in compliance with label instructions. Cleaning agent shall contain no solvents, phosphates or release VOCs and shall be environmentally friendly.

PART 3 - EXECUTION

3.1 DUCT CLEANING, GENERAL

A. The project shall be supervised at all times by a person who has been certified by NADCA as an Air Systems Cleaning Specialist (ASCS).

B. The contractor shall verify field conditions before start of work.

C. Provide all labor, materials, facilities, equipment and services to thoroughly clean HVAC systems serving the natatorium space located at the Houston Gymnasium.

D. The cleaning work for the HVAC systems is to include but not limited to ALL of the following systems and components serving the natatorium:

1. Supply, return, outside air and exhaust air ductwork, including ductwork plenums, branches, risers, etc. both exposed and concealed.

2. Outside air intake and exhaust air relief plenums
3. Fire and volume dampers, turning vanes and other duct accessories located within existing ductwork.

E. Contractor will provide all labor, material, and services to obtain access to HVAC units and associated components including:

1. Removal of ceiling tiles.

2. Installation of new ductwork access panels and removal/replacement of existing panels. Ductwork access panels shall meet the requirements listed in specification section 233300 “Ductwork Accessories”.

F. The Contractor will repair and replace to match existing materials where access to walls or ceilings was made, or damage occurs, including but are not limited to:

1. Ductwork and components
2. Insulation
3. Electric control components
4. Others as applicable

G. The Contractor, on the basis of field inspections and review, must determine the methods of cleaning the HVAC systems and its components, to minimize access openings, and prevent any damage to the system and its operation. Upon completion of the initial inspection the contractor will notify the Owner’s Representative / Project Engineer of the proposed methods and their effects on the system.

H. Reset all balancing dampers to original settings if moved during work. Be sure to mark original position so that during the final inspection original settings can be field verified.

I. Report to Project Engineer any system defects discovered during the cleaning operation which will require repair to an HVAC system (e.g. equipment, ductwork, dampers, registers, etc.).

3.2 PRE-CLEANING PREPARATIONS

A. Prior to start of work, the HVAC system is to be carefully inspected and checked for all conditions affecting the cleaning. Defects are to be reported in writing to the Project Engineer and work will not proceed until all defects have been documented. Commencement of work will constitute acceptance of the conditions of the area to which the cleaning work is to be performed and all defects in work resulting from such accepted service will be corrected by this trade without additional expense to the owner.

B. Disassemble all removable items as required for access to work area. Store the removables in a storage area until the completion of the cleaning work.

C. Fire protection devices (such as smoke detectors, panel, etc.) shall be protected prior to cleaning procedures. They are to be cleaned and tested at the conclusion of work.

D. The Contractor shall coordinate the shutdown and reactivating of the fire alarm system to avoid accidental alarms during cleaning process and related work.

E. The Contractor shall coordinate the shutdown of the air handling equipment with the Owner before starting work, and shall conform to OSHA requirements regarding fan motor disconnect lock-out/tag-out.
3.3 CLEANSING AND REMOVAL METHODS

A. Cleaning and removal methods and procedures shall use ACR-2006 as a guideline throughout the project. In addition, methods and procedures which require the least amount of access openings, without compromising proper agitation and source removal, are required. Contractors are to provide detailed procedures in their submittals. Deviations from specified methods of removal must be approved by the Project Engineer prior to their implementation.

B. Debris Collection Equipment:

1. Equipment used shall be portable and sized to enter the areas easily.

2. The collection systems shall be self-contained units, with the appropriate components to adequately collect dirt and debris loosened from the ductwork. Debris collection is to be performed by a high powered vacuum system with three stages of filtration. The final stage shall be a HEPA filter. HEPA filter efficiency shall be 99.97% @ 0.3 micron.

3. The collection system shall be capable of producing a minimum of 2,500 cfm, 0.42" water gauge negative static pressure and 0.25" water gauge velocity pressure in the area of ductwork to be cleaned.

4. Where contact vacuuming is required, the equipment used shall be HEPA filtered vacuums. These vacuums shall be capable of at least 95 cfm at 88” water column. The vacuum shall have at least four (4) stages of filtration with the final stage being a HEPA filter.

C. Mechanical Agitation (ductwork)

1. The Contractor is required to remove all debris from the inside surface areas, e.g. the top, bottom, and sides of rectangular duct, and the entire inside circumference of round and flat oval ductwork by creating the least amount of access openings possible. The following restrictions for agitation tools shall be adhered to:

   a. High power/volume vacuum alone is not an acceptable method of agitation.

   b. Agitation systems shall meet the following:

      1.) The system is capable of thoroughly cleaning (and sanitizing) up to 50 lineal feet of ductwork in each direction per access point. Exceptions to this requirement will apply only when the removal of the debris requires more aggressive agitation.

      2.) A minimum of 150 cubic feet per minute (cfm) of compressed air at 110 pounds per square inch (psi) must be supplied to the air tool or nozzle in order to effectively dislodge the built-up debris.

      3.) The air tool or nozzle shall be able to follow the contours of the ductwork, i.e. the tool must be able to come in contact with all sides/surfaces of the interior of the duct.

      4.) The air tool or nozzle shall be capable of dispensing coatings or sanitizing solutions to cover the entire interior surface areas of the ductwork without creating additional access openings in order to maintain the integrity of the duct work.

      5.) Where ductwork is large enough, and able to support the weight of a worker, hand tools and HEPA vacuums may be used. If workers enter the...
inside of the duct they must follow the OSHA confined space requirements (OSHA 29 CFR 1910.146). Collection equipment must be used during this process to assure capture of any residual or airborne debris.

D. Open Ductwork:

1. During the cleaning process, provide temporary closures of metal or taped polyethylene on open ductwork, or around the open ceiling area to prevent the dust during the cleaning process from dispersing throughout the work area.

E. Controlling odors:

1. All responsible measures shall be taken to control any and all offensive odors and/or mist vapors generated during the cleaning process.

F. Containment:

1. Precautions must be taken to ensure that debris is not dispersed outside the air conveyance system (ACS) during the cleaning process.

G. Volume Dampers, Fire Dampers and Duct Accessories:

1. Duct mounted volume and fire damper sets are to be marked to their current setting, then inspected and cleaned. External moving parts are to be treated with an approved dry lubricant material. After cleaning, the dampers shall be repaired as necessary to insure proper operation and returned to original settings. Contractor shall indicate locations of damaged and/or repaired dampers.

3.4 RESTORATION, REPAIRS AND INSTALLATION

A. Any damages to the finishes, floor, walls or any other item or fixture that has been the result of actions by the contractor personnel is to be repaired to their original condition without any additional costs.

B. Reinstall existing and install new accessories in accordance with manufacturer's instructions.

C. Demonstrate re-setting of fire and balancing dampers to authorities having jurisdiction and Owner's representative

D. Provide duct access doors for inspection and cleaning before and after fire dampers, volume dampers, and elsewhere if required. Provide suitable size access doors for hand access or shoulder access where necessary.

3.5 VERIFICATION

A. Verification of HVAC System Cleanliness

1. Cleanliness verification shall be performed after an HVAC system component has been cleaned and prior to the application of any treatment and/or the component being used in operation. A visual inspection must be used to assess that the HVAC system is visibly clean. An interior surface is considered visibly clean when it is free from non-adhered substances and debris. If a component is visibly clean then no further cleanliness verification is required.
a. In the event there is disagreement concerning whether the surface is visibly clean, contractor will conduct Surface Comparison Testing, as per section 13.2 of ACR 2006.

2. The Contractor will submit 3 copies of the final report to the Project Engineer / owner. The report shall contain the following:

   a. Success of the cleaning project, as verified through visual inspection.

   b. The report shall contain photographic or video documentation of representative areas of the ductwork systems cleaned as part of the project. This photo documentation report may contain both before and after pictures verifying the systems are clean, but at a minimum must contain after pictures that show the system is free from non-adhered substances and debris.

   c. Areas of the system found to be damaged, in need of repair, and / or requiring more aggressive cleaning.

END OF SECTION
SECTION 233400 FANS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types fans:

1. Centrifugal fans for indoor installations.
2. Inline centrifugal fans.
5. Propeller fans.

1.2 SUBMITTALS

A. Product data for selected models, including specialties, accessories, and 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 fan accessories.
4. Materials gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

C. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.

D. Maintenance data fans for inclusion in Operating and Maintenance Manual.

1.3 QUALITY ASSURANCE

A. UL Compliance: Fans and components shall be UL listed and labeled.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

1.4 EXTRA MATERIALS

A. Furnish one additional complete set of belts for each belt-driven fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Centrifugal Fans:
2. Inline Centrifugal Fans:
   a. Cook (Loren) Co.
   b. Greenheck Fan Corp.
   c. Jenn Industries Inc.

3. Centrifugal Roof Ventilators:
   a. Carnes Company, Inc.
   b. Cook (Loren) Co.
   c. Greenheck Fan Corp.

4. Propeller Fans:
   b. Cook (Loren) Co.
   c. Greenheck Fan Corp.

2.2 SOURCE QUALITY CONTROL

A. Testing Requirements: The following factory tests are required:
   2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2.3 FANS, GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
   1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan=s class.

C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

D. Belts: Oil-resistant, nonsparking, and nonstatic.
E. Motor and Fan Wheel Pulleys: Adjustable pitch for use with motors. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

F. Shaft Bearings: Provide type indicated, having a median life “Rating Life” (AFBMA (L50)) of 200,000, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.

G. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.

H. Motors:

1. Refer to other Sections for motor equipment.

2.4 CENTRIFUGAL FANS

A. General Description: Belt- or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

B. Housings: Fabricated from formed and reinforced galvanized steel panels to form curved scroll housings with continuously welded or deep-locked seams and access doors or panels to allow access to internal parts and components.

1. Inlet Cones: Spun metal.
3. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

C. Fan Wheels: Double-width, double-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.

2. Blade Type: Backward-curved, airfoil type.
3. Blade Type: Forward-curved, airfoil type.

D. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block type ball bearings.

E. Accessories: The following accessories are required where indicated:

1. Inlet Screens: Heavy wire mesh screens, mounted inside of shaft bearings.
2. Discharge Dampers: Heavy-gage steel, opposed blade design, with linkage for manual or automatic operation.
3. Drain Connections: Threaded, 3/4-inch NPS, capped nipple installed at lowest point of housing.
4. Shaft Cooler: Metal disc between bearings and fan wheel, designed to dissipate heat from shaft.
5. Shaft Seals: Air-tight seals installed around shaft on drive side of single-width fans.
2.5 TUBULAR CENTRIFUGAL FANS

A. General Description: Tubular, inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.

B. Housings: Fabricated from formed and reinforced galvanized steel panels with welded seams.
   1. Duct Connections: Spun inlet cones with flange removable for access to internal parts, and an outlet flange.
   2. Mounting Brackets: Suitable for horizontal or vertical mounting.
   4. Fan Wheels: Single-width, single-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.
      b. Blade Type: Backward-curved, airfoil type.

C. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.

D. Accessories: The following accessories are required where indicated:
   1. Companion Flanges: For inlet and outlet connections.
   2. Belt Guard: Manufacturer’s standard to meet OSHA requirements.
   3. Ceiling Brackets: Structural angles welded and drilled for hanger rod attachment.
   4. Access Doors: Located over wheel in an accessible position, hinged and having latch-type handles; flush mounted for uninsulated housings, raised-mounted for insulated housings.
   5. Inlet and Outlet Screens: Removable, heavy wire mesh.

2.6 INLINE CENTRIFUGAL FANS

A. General Description: Inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.

B. Housing: Split, spun-aluminum housing, with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

D. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Wheel: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories: The following accessories are required as indicated:
1. Companion Flanges: For inlet and outlet duct connections.
3. Speed Control: Variable speed switch with on-off control and speed control for 100 to 50 percent of fan air delivery.

2.7 CENTRIFUGAL ROOF VENTILATORS

A. General Description: Belt-driven or direct-drive as indicated, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
   1. Pulleys: Cast-iron, adjustable-pitch.
   3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
   4. Fan and motor isolated from exhaust air stream.

E. Motor shall be open drip proof type.

F. Accessories: The following items are required as indicated:
   1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
   2. Bird Screens: Removable 1/2-inch mesh, 16-gage, aluminum or brass wire.
      b. Frame: Extruded aluminum, with waterproof, felt blade seals.
      c. Linkage: Nonferrous metals, connecting blades to counter weight or operator.
      d. Operators: Manufacturer’s standard electric motor.
   4. Roof Curbs: Prefabricated, heavy-gage, galvanized steel; mitered and welded corners; 2-inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
      a. Overall Height: 24 inches.

2.8 CEILING-MOUNTED VENTILATORS

A. General Description: Centrifugal fan designed for installation in ceiling, wall, or concealed inline applications.
B. Housing: Galvanized steel lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Remote Fan Speed Control: Solid state, capable of controlling fan speed from full speed to approximately half speed.

G. Accessories: Manufacturer’s standard roof jack, wall cap, and transition fittings as indicated.

2.9 PROPELLER FANS

A. General Description: Belt-driven or direct-drive propeller fans as indicated consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories.

B. Housings: Galvanized, sheet steel with flanged edges, and integral orifice ring.

C. Wheels: Formed-steel blades riveted to a heavy-gage steel spider bolted to cast-iron hub.


E. Drive Assembly: Direct-drive or belt-driven as indicated.

F. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.
3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
4. Motor and Drive Assembly: Resiliently mounted to the housing.

G. Accessories: The following accessories are required as indicated:

2. Motor operated shutters with aluminum blades in steel frames, motor mounted on discharge side of fan.

2.10 MOTORS

A. Torque Characteristics: Sufficient to accelerate the driven loads satisfactorily.

B. Motor Sizes: Minimum sizes and electrical characteristics as indicated. If not indicated, large enough so that the driven load will not require the motor to operate in the service factor range.

C. Temperature Rating: 50°C maximum temperature rise at 40°C ambient for continuous duty at full load (Class A Insulation).
D. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

E. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design B. Provide permanent-split capacitor classification motors for shaft-mounted fans and capacitor start classification for belted fans.


2. Bearings: The following features are required:
   a. Ball or roller bearings with inner and outer shaft seals.
   b. Permanently sealed.
   c. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

3. Enclosure Type: The following features are required:
   a. Open dripproof motors where satisfactorily housed or remotely located during operation.
   b. Guarded dripproof motors where exposed to contact by employees or building occupants.

4. Overload protection: Built-in, automatic reset, thermal overload protection.

5. Noise rating: Quiet.

6. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, Test Method B. If efficiency not specified, motors shall have a higher efficiency than “average standard industry motors” in accordance with IEEE Standard 112, Test Method B.

7. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, and special features.

F. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in other Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fans.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install fans level and plumb, in accordance with manufacturer’s written instructions. Support units as described below, using the vibration control devices indicated. Vibration control devices are specified in Division 23 Section “Mechanical Vibration Controls and Seismic Restraints”.
1. Support floor-mounted units on concrete equipment bases using housed spring isolators. Secure units to anchor bolts installed in concrete equipment base.

2. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
   a. Installation of roof curbs is specified in other Sections.

3. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

3.3 EQUIPMENT BASES
   A. Construct concrete equipment pads as follows:
      1. Coordinate size of equipment bases with actual unit sizes provided. Construct base 4 inches larger in both directions than the overall dimensions of the supported unit.
      2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
      3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
      4. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C 150, 4,000 psi compressive strength, and normal weight aggregate.

3.4 CONNECTIONS
   A. Duct installations and connections are specified in other Sections. Make final duct connections with flexible connections.
   B. Electrical Connections: The following requirements apply:
      1. Electrical power wiring is specified in other Divisions.
      2. Temperature control wiring and interlock wiring are specified in Division 23.
      3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.5 FIELD QUALITY CONTROL
   A. Manufacturer’s Field Inspection: Arrange and pay for a factory-authorized service representative to perform the following:
      1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
      2. Prepare a written report on findings and recommended corrective actions.
3.6 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.7 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.

2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.

7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
   a. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Division 23 Section “Testing, Adjusting, and Balancing” for procedures for air-handling-system testing, adjusting, and balancing.

3.8 DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner’s maintenance personnel on the following:
1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals.

   B. Schedule training with at least 7 days’ advance notice.

END OF SECTION
SECTION 233600  AIR TERMINALS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1.2 SUBMITTALS

A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated. Include a schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating air outlets with other items installed in ceilings.

D. Maintenance Data: List of parts for each type of air terminal and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers’ systems with equal performance characteristics may be considered.

B. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.
   1. The Terms “Listed” and “Labeled”: As defined in NFPA 70, Article 100.


D. Comply with NFPA 70 for electrical components and installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering air terminals that may be incorporated into the Work include, but are not limited to, the following:
   1. Acutherm.
   2. Air System Components; Krueger Div.
   3. Anemostat Products Div.
   4. Carnes Co., Inc.
   5. Carrier Corp.
7. Nailor Industries Inc.
8. Phoenix Controls Corp.
10. Trane Co. (The).
11. Trox USA, Inc.
15. Price Industries.

2.2 SINGLE-DUCT AIR TERMINALS

A. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.

B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
   1. Upstream Pressure Side: 0.0239-inch (0.6-mm) steel.
   2. Downstream Pressure Side: 0.0179-inch (0.45-mm) steel.

C. Casing Lining: Minimum of 1-inch- (13-mm-) thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. (24-kg/cu. m) density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
   1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.

D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.

E. Plenum Air Outlets: S-slip and drive connections.

F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.

G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: 3 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

H. Round Outlet: Discharge collar matching inlet size.

I. Hot-Water Heating Coil: 1/2-inch (13-mm) copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig (1380 kPa); and factory installed.

J. Controls: Damper operator, thermostat, and other devices compatible with temperature controls specified in other Sections.

K. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor provide control with the following features:
   1. Proportional plus integral control of room temperature.
   2. Time-proportional reheat-coil control.
   3. Occupied/unoccupied operating mode.
   4. Remote reset of airflow or temperature set points.
   5. Adjusting and monitoring with portable terminal.
   6. Communication with temperature-control system specified in other Sections.
2.3 SOURCE QUALITY CONTROL

A. Testing Requirements: Test and rate air terminals according to ARI 880, “Industry Standard for Air Terminals.”

B. Identification: Label each air terminal 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 terminals level and plumb, according to manufacturer’s written instructions, rough-in drawings, original design, and referenced standards; and maintain sufficient clearance for normal service and maintenance.

B. Connect ductwork to air terminals according to other Sections.

3.2 CONNECTIONS

A. Install piping adjacent to air terminals to allow service and maintenance.

B. Hot-Water Piping: Connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Electrical: Comply with applicable requirements in other Sections.

D. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 CLEANING

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

3.5 COMMISSIONING

A. Verify that installation of each air terminal is according to the Contract Documents.

B. Check that inlet duct connections are as recommended by air terminal manufacturer to achieve proper performance.

C. Check that controls and control enclosure are accessible.

D. Verify that control connections are complete.
E. Check that nameplate and identification tag are visible.

F. Verify that controls respond to inputs as specified.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel as specified below:

1. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Review data in the maintenance manuals. Refer to Division 1 Section “Contract Closeout.”

3. Review data in the maintenance manuals. Refer to Division 1 Section “Operation and Maintenance Data.”

4. Schedule training with Owner, through Architect, with at least 7 days’ advance notice.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

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

1.2 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.3 SUBMITTALS

A. Product Data: For each model indicated, include the following:

1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.

2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.

3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.

4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

B. Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.

C. Samples for Initial Selection: Manufacturer’s color charts showing the full range of colors available for diffusers, registers, and grilles with factory-applied color finishes.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers’ products with equal performance characteristics may be considered.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Diffusers, registers, and grilles are scheduled on Drawings.

B. Acceptable Manufacturers:

1. Titus
2. Anemostat
3. Carnes
4. Kreuger
5. Tutle & Bailey
6. Price Industries

2.2 SOURCE QUALITY CONTROL

A. Testing: Test performance 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. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer’s written instructions, Coordination Drawings, original design, and referenced standards.

B. 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 practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Engineer for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connection 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.

3.4 CLEANING

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

A. Linear Slot Diffuser - Standard Construction.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following:
   a. Air Systems Components; Krueger Div.
   b. Anemonstat Products; Dynamics Corp. of America.
   c. Carnes Co. Inc.
   f. Nailor Industries Inc.
   g. Titus.


5. Duct Connection Size: See drawings.


8. Face Style: Linear.


11. Accessories: Include the following:
    a. Insulated plenum.

B. Diffuser - Standard Construction.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following:
   a. Air Systems Components; Krueger Div.
   b. Anemonstat Products; Dynamics Corp. of America.
   c. Carnes Co. Inc.
   f. Nailor Industries Inc.
   g. Price Industries.


5. Duct Connection Size: See drawings.


8. Face Style: Linear.


11. Accessories: Include the following:
    a. Insulated plenum.
    b. Frame suitable for ceiling type or duct construction.
3.6 REGISTER SCHEDULE
A. Register.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Air Systems Components; Krueger Div.
   b. Anemostat Products; Dynamics Corp. of America.
   c. Carnes Co. Inc.
   f. Nailor Industries Inc.
   g. Titus.
   h. Price Industries.
5. Rear Blade Arrangement: Adjustable vertical.
7. Damper Type: Adjustable opposed-blade assembly.
8. Accessories:
   a. Frame suitable for ceiling type or duct construction.
   b. 12 Gage lattice with 13/16-inch square holes on 1-inch centers for Security Register only.

END OF SECTION
SECTION 235100  BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1  SUMMARY
   A. This Section specifies double wall metal vents and accessories for gas-fired appliances.
   B. This Section specifies refractory lined metal breechings, chimneys, and accessories.

1.2  SUBMITTALS
   A. Product Data:
   B. Shop Drawings:
   C. Quality Control Submittals:
      1. Certificates: Submit certificates of materials compliance with specified ASTM, UL, and ASHRAE requirements.
      2. Certificates: Submit Welders’ Qualification Certificates.
      3. Certificates: Submit complete engineering report certifying that stacks meet the design wind and seismic loads.

1.3  QUALITY ASSURANCE
   A. Welder’s Qualifications: All welders shall be certified in accordance with AWS Standard D9.1, Specifications for Welding Sheet Metal.
   B. Codes and Standards:
      2. UL: Comply with applicable portions of UL safety standards; provide products which have been UL listed and labeled.
      3. SMACNA: Comply with SMACNA Low Pressure Duct Standards for fabricated breeching and smokepipe.
      4. AWS: Comply with AWS Structural Welding Code for welders’ qualifications, welding details, and workmanship standards.
      5. ASHRAE: Comply with the ASHRAE Equipment Handbook, Chapter 27, for Chimney, Gas Vent, and Fireplace Systems, material requirements and design criteria.

PART 2 - PRODUCTS

2.1  DOUBLE WALL METAL VENTS
   A. Type B Gas Vents:
      1. Acceptable Manufacturers:
a. American Metal Products Co.; Div. of Masco Corp.
b. General Products Co., Inc.
d. Selkirk Metalbestos.

2. Description: Double wall gas vents, UL listed for Type B, consisting of an inner pipe of stainless steel, and outer pipe of galvanized sheet steel, with the following minimum thicknesses:

<table>
<thead>
<tr>
<th>Size</th>
<th>Inner Pipe</th>
<th>Outer Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round, up to 6&quot;</td>
<td>0.012&quot;</td>
<td>28 gage</td>
</tr>
<tr>
<td>Round, 7&quot; to 18&quot;</td>
<td>0.014&quot;</td>
<td>28 gage</td>
</tr>
<tr>
<td>Round, 20&quot; to 24&quot;</td>
<td>0.018&quot;</td>
<td>26 gage</td>
</tr>
<tr>
<td>Oval, up to 4&quot;</td>
<td>0.012&quot;</td>
<td>28 gage</td>
</tr>
<tr>
<td>Oval, 5&quot; to 6&quot;</td>
<td>0.014&quot;</td>
<td>28 gage</td>
</tr>
</tbody>
</table>

3. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners, fabricated of similar materials and designs as vent pipe straight sections.

B. All Steel, Positive Pressure, Double Wall Vents:

1. Acceptable Manufacturers:
   a. Selkirk Metalbestos.
   b. Van Packer
   c. Stacks, Inc., Div of Air Management, Inc.
   d. General Products Co, Inc.
   e. Hart & Cooley

2. Description: UL-labeled double wall metal stacks for use with building heating equipment burning gas, solid, or liquid fuels as described in NFPA 211.

3. Construction: 1" minimum air space between walls; inner jacket of Type 304 stainless steel, 0.035" thick; outer jacket of stainless steel of the following thickness:
   a. Size 10" to 24": 0.025" thick.
   b. Size 28" to 48": 0.034" thick.

4. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners fabricated of similar materials and designs as vent pipe straight sections.

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2.2 REFRACTORY LINED METAL BREECHINGS AND CHIMNEYS

A. Acceptable Manufacturers:

1. Power Pac Enterprises, Ltd.
2. Susquehanna Concrete Products, Inc.
3. Van-Packer Co.
B. Design Loads:
   1. Wind Loading: 110 mph.
   2. Seismic Loading: Zone 1.

C. Steel Jacket:
   1. Chimney Outer Jacket:
      a. 11 gage stainless steel with welded seam joint.

D. Refractory Lining:
   1. Tested under UL Standard 959 for temperature and acid resistance, and bearing the testing laboratory label.
   3. Acid Extraction: Maximum of 0.2 percent.
   5. Bond refractory lining to steel jacket so finished product may be shipped, handled, and installed with no separation.
   6. Thickness: Minimum of 2”.

E. Finishing: Factory-applied, high heat resistant paint, color as selected by the Engineer at shop submittal.

F. Accessories: Provide accessories bearing UL label.
   1. Base Section: Provide acid resistant coated cast-iron anchor lugs for securing stack to foundation.
   2. Cleanout Section: Provide smoke-tight cleanout section with gasketed and bolt-tightened inspection plate. Weld neck to stack section.
   3. Tee or Wye Section: smoke-tight tee or wye as indicated for breeching connection, with welded joints, refractory lining, finished with smooth transition, and with no exposed metal on inside.
   4. Spark Screen: Type 304 stainless steel, 16 gage, 1/2” x 1/2” mesh, with Type 304 stainless steel rolled angle and drawband.
   5. Guy bands: 8” wide bands of same material as jacket, fastened with nuts and bolts for tight fit.
   6. Roof Penetration: factory fabricated thimble, flashing, and counterflashing.

G. Fabrication:
   1. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.
2. Fabricate components with centrifugally cast lining in lengths suitable for connection with drawband. Bond refractory with calcium aluminate cement.

3. Fabricate chimneys with anchor lugs, cleanout, T-sections, flashing and counterflashing, and provisions for support, expansion, and contraction.

4. Fabricate breechings with support lug for attachment to building structure so as not to exceed permissible loading at appliance and chimney.

2.3 FABRICATED METAL BREECHINGS AND CHIMNEYS

A. Materials:

1. Black, carbon, hot-rolled steel complying with ASTM A 569, except breechings less than 24” diameter (or longest side) may be galvanized sheet steel complying with ASTM A 527, lock forming quality with ASTM A 525, G90 zinc coating, mill phosphated.

2. Minimum gages for corresponding sizes as indicated (diameter or longest side dimension):

<table>
<thead>
<tr>
<th>SIZES</th>
<th>THICKNESS - GAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 12”</td>
<td>18</td>
</tr>
<tr>
<td>13” to 24”</td>
<td>16</td>
</tr>
<tr>
<td>25” to 36”</td>
<td>14</td>
</tr>
<tr>
<td>37” to 60”</td>
<td>12</td>
</tr>
<tr>
<td>over 60”</td>
<td>10</td>
</tr>
</tbody>
</table>

B. Fabrication:

1. Shop fabricate breechings and chimneys in as complete as possible to minimize field welding. Match-mark sections for field assembly and coordination of installation.

2. Longitudinal Seams: welded, except longitudinal seams for breechings less than 24” diameter (or longest side) may be Acme grooved type.

3. End joints: weld, lap and bolt, or use companion flanges; except breechings less than 24” diameter (or longest side) may have end joints beaded and crimped.

4. Reinforcement: Reinforce rectangular breechings with angle frames as follows for corresponding long side dimensions; and reinforce round breechings with either flanged girth joints or angle frames as follows for corresponding diameter:

<table>
<thead>
<tr>
<th>SIZES</th>
<th>REINFORCING</th>
<th>INTERVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 30”</td>
<td>No reinforcing required.</td>
<td></td>
</tr>
</tbody>
</table>

5. Fabricate breeching and chimneys fittings to match adjoining materials. Except as otherwise indicated, fabricate elbows with centerline radius equal to associated breeching width. Limit angular tapers to 20 degrees maximum for expanding tapers. Install accessories during fabrication to greatest extent possible.

C. Accessories and Specialties:

1. Provide accessories and specialties of types and sizes required to comply with breeching requirements including proper connection of equipment.
2. Barometric Dampers: adjustable, self-actuating draft dampers, where indicated, full size of breeching.

3. Cleanout Doors: same gage as breeching; size and location as indicated.

4. Thermally Actuated Vent Dampers: same size as draft hood collar; constructed of stainless steel housing and brackets. Secure 4 quadrants to brackets constructed of corrosion resistant bi-metal. Secure brass weights to quadrants to prevent vibrations and noise during high draft conditions. Test units in accordance with AGA standards, and certify design complies with ANSI Z21.68.

   a. Available Manufacturer: Subject to compliance with requirements, provide thermally actuated vent dampers of one of the following or an approved equal:

      (1) American Metal Products Co.; Div. of Masco Corp.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOUBLE WALL CONNECTORS, BREECHINGS, AND VENTS

   A. Install Type B gas vents in accordance with manufacturer’s installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.

   B. Install all steel, positive pressure, double wall gas vents in accordance with manufacturer’s installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.

   C. Seal joints between sections of positive pressure vents in accordance with manufacturer’s installation instructions, and using only sealants recommended by manufacturer.

   D. Support vents at intervals recommended by the manufacturer to support the weight of the vent and all accessories, without exceeding loading of appliances.

3.2 INSTALLATION OF REFRACTORY LINED BREECHINGS AND CHIMNEYS

   A. Assemble and erect stack sections and accessories in accordance with the manufacturer’s written instructions and in compliance with UL listing. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

   B. Joints:

      1. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.


   C. Erect chimneys level and plumb to finished tolerance of no more than 1” out of plumb from top to bottom.

   D. Erect breechings with a slope down to appliance, with condensate drain connection. Pipe drain line to nearest open site drain.
3.3 INSTALLATION OF FABRICATED BREECHINGS AND CHIMNEYS

A. Assemble and erect fabricated breechings and chimneys in accordance with SMACNA Low Pressure Duct Construction Standards.


C. Align breechings accurately at connections, with a smooth internal surface and a 1/8” misalignment tolerance.

D. Slope breechings down to appliances and provide a condensate drain connection. Pipe drain line to nearest open site drain.

E. Install concrete inserts for support of breeching in coordination with formwork.

F. Install accessories, dampers, fans, equipment, controls, and other supports.

G. Anchor breechings to building structure with bolts, concrete inserts, steel expansion anchors (not lead-shield type), welded studs, C-clamps or special beam clamps.

H. Vertical Breechings:
   1. Support at 12 foot intervals, by attachment to adjacent vertical structural surfaces or by direct bearing at floor penetrations and similar locations.
   2. Breechings up to 24” x 20”: use 1-1/2” x 16 gage straps or formed angles.
   3. Breechings larger than 24” x 20”: use steel angle brackets 1” x 1/8” for sizes up to 36” x 18”; 1-1/2” x 1/8” for larger sizes.

I. Horizontal breechings located against structural walls and other similar adjacent vertical surfaces:
   1. Support at 8 foot intervals for units up to 40” horizontal dimensions, and 4 foot intervals for larger breechings.
   2. Where width is less than height: support with 1-1/2” x 16 gage straps.
   3. Where width is more than height: support with shelf-type fabricated angle brackets; 1” x 1/8” for widths up to 18”; 1-1/2” x 1/8” for greater widths.

J. Horizontal Rectangular Breechings:
   1. Support from overhead structure with hangers at 10 foot intervals for unit widths up to 60”, and 8 foot intervals for larger breechings.
   2. Support breechings directly with 1” x 16 gage straps up to 60” width, and with 1-1/2” x 12 gage straps up to 96” width, bolted to breechings.

K. Trapeze Hangers:
   1. Support breechings with horizontal angle members and vertical support members of sizes listed below (long side dimensions):
      a. Up to 30” size: 1” x 1/8” angle, with 1” x 18 gage or 1/4” diameter hangers.
L. Horizontal Round Breechings:

1. Support with girth strap and strap hanger (of same size); except for sizes over 50" in diameter. Install pair of strap hangers bolted to opposite sides of angle reinforcing rings or flanged joints. Support breechings at 10 foot intervals with hangers as follows for corresponding diameters.

   a. Up to 30" diameter: 1" x 16 gage strap hangers.

3.4 INSTALLATION OF DAMPERS

   A. Install barometric and thermostatically operated dampers in accordance with manufacturer's instructions. Locate as close to draft hood collar as possible.

3.5 ADJUSTING AND CLEANING

   A. Clean breechings internally during installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.

3.6 PROTECTION

   A. Temporary Closure: At ends of breechings and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until installations are completed.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes high-efficiency boilers for heating hot water.

1.2 SUBMITTALS

A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Source Quality Control Tests and Inspection Reports: Indicate and interpret test results for compliance with performance requirements before shipping.

D. AGA design certificates, for information.

E. Maintenance Data: Include in the maintenance manuals specified in Division 1. Include parts list, maintenance guide, and wiring diagrams for each boiler.

1.3 QUALITY ASSURANCE

A. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The Terms “Listed” and “Labeled”: As defined in NFPA 70, Article 100.


B. AGA Compliance: Design certified by AGA; tests and ratings according to AGA requirements.

C. ASME Compliance: Fabricate and label boilers to comply with the ASME Boiler and Pressure Vessel Code: Section VIII, “Pressure Vessels,” Division 1.

D. Comply with NFPA 70 for electrical components and installation.

1.4 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section “Cast-in-Place Concrete.”

1.5 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: Submit a written warranty, executed by the contractor for heat exchanger.

1. Warranty Period: Manufacturer’s standard, but not less than 5 years from date of Substantial Completion.

2. Warranty to commence after commissioning and complete system acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fire-Tube Condensing Boilers:
   a. Lochinvar Corp.
   b. Trianco-Heatmaker, Inc.
   c. Fulton Boiler Works, Inc.
   d. Aerco International, Inc

2.2 PACKAGED UNITS

A. Description: Factory-assembled and -tested modules include combustion-air inlet chamber, prepurge and postpurge blower assembly, air-gas fuel control valve, combustion chamber, stainless steel heat exchanger, and exhaust; with insulated jacket around module and unit-mounted electrical control panel with operation sequence indicator lights.

B. Type: Fire-tube, gas-fired, condensing-type hot-water boiler with capacities and accessories as scheduled.

C. Fuel: Natural gas.

2.3 CONTROLS

A. Controller: Solid state, with pressure-sensing flame safeguard system, ignition transformer, spark plug, manual gas shutoff valve, system-pressure-controlled regulator, automatic redundant control valves, high-limit water temperature controller, ASME-approved safety-relief valve, and temperature and pressure gage.

B. Operating Temperature Control: Electronic-operating temperature controller maintains boiler water temperature, with electronic primary and outdoor sensors. Reset ratio of outside-air temperature change to discharge control point change adjustable from 1:2 to 100:1, with adjustable initial set point from 80 to 230 deg F (27 to 110 deg C). Mounted in NEMA 250, Type 1, wall-mounted enclosure with full cover.

2.4 ACCESSORIES

A. Include the following list of manufacturer’s standard accessories:
   1. Low-water cutoff and manual-reset high-limit control.
   2. Vent terminal plates.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV for low-pressure boilers.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine area to receive boiler for compliance with requirements for installation tolerances and other conditions affecting boiler performance. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install boilers level and plumb, according to manufacturer’s written instructions and referenced standards.
B. Install gas-fired boilers according to NFPA 54.
C. Support boilers on 4-inch-(100-mm-) thick concrete base, 4 inches (100 mm) larger on each side than base of unit.
D. Assemble units and parts shipped loose or disassembled.
E. Install electrical devices furnished with boiler, but not specified to be factory mounted.

3.3 CONNECTIONS
A. Connect gas piping full size to boiler gas-train inlet with union.
B. Connect air-intake and exhaust piping to boiler, size as recommended by manufacturer. Use Schedule 40 CPVC pipe and fittings for exhaust and for supply, with solvent-cemented joints. Pitch toward boiler minimum of 2 percent or as indicated. Provide termination as indicated.
C. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
D. Electrical: Comply with applicable requirements in Division 26 Sections.
E. Ground equipment.
   1. 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.

3.4 FIELD QUALITY CONTROL
A. Manufacturer’s Field Service: Engage a factory-authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
B. Hydrostatically test assembled boiler and piping, according to applicable sections of the ASME Boiler and Pressure Vessel Code.

3.5 CLEANING
A. Flush and clean boilers on completion of installation, according to manufacturer’s written instructions.
B. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer’s touchup paint.

3.6 COMMISSIONING

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

B. Verify that installation is as indicated and specified.
   1. Verify that electrical wiring installation complies with manufacturer’s submittal and installation requirements specified in other Sections. Do not proceed with boiler startup until wiring installation is acceptable to equipment Installer.

C. Complete manufacturer’s installation and startup checklist and verify the following:
   1. Boiler is level on concrete base.
   2. Flue and chimney are installed without visible damage.
   3. No damage is visible to boiler jacket, refractory, or combustion chamber.
   4. Pressure-reducing valves are checked for correct operation and specified relief pressure. Adjust as required.
   5. Clearances have been provided and piping is flanged for easy removal and servicing.
   6. Heating circuit pipes have been connected to correct ports.
   7. Labels are clearly visible.
   8. Boiler, burner, and flue are clean and free of construction debris.
   9. Pressure and temperature gages are installed.
  10. Control installations are completed.

D. Ensure pumps operate properly.

E. Check operation of pressure-reducing valve on gas train, including venting.

F. Check that fluid-level, flow-switch, and high-temperature interlocks are in place.

G. Start pumps and boilers, and adjust burners to maximum operating efficiency.
   1. Fill out startup checklist and attach copy with Contractor Startup Report.
   2. Check and record performance of factory-provided boiler protection devices and firing sequences.
   3. Check and record performance of boiler fluid-level, flow-switch, and high-temperature interlocks.
   4. Run-in boilers as recommended or required by manufacturer.
   5. Measure and record gas pressure on manifold.
6. Measure and record combustion-air temperature at inlet to burner.

7. Measure and record flue-gas temperature at boiler discharge.

H. Measure and record water flow rate, pressure drops, and temperature rise through each boiler.

I. Inspect expansion tank, makeup water meter, tank pressure, pressure-reducing valve, water level, and backflow preventer.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel as specified below:

1. Operate boiler, including accessories and controls, to demonstrate compliance with requirements.

2. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

3. Review data in the maintenance manuals.

4. Schedule training with Owner with at least 7 days’ advance notice.

END OF SECTION
SECTION 235700 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes heat exchangers for HVAC applications.

1.2 SUBMITTALS

A. Product data for each heat exchanger, including rated capacities, pressure drop, weights (shipping, installed, and operating), and installation and startup instructions.

B. Shop drawings detailing heat exchanger installation, including plans, elevations, and sections. Indicate heat exchanger dimensions, rough-in requirements, weight loadings and distribution, and clearances required around and between construction elements such as beams, columns, and walls.

C. Coordination drawings, including floor plans and sections drawn accurately to scale. Show maintenance space requirements, layout, and relationships between components and adjacent structural and mechanical elements. Show structural supports, support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Qualification data for firms and persons specified in the “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Maintenance data for heat exchangers to include in the operation and maintenance manual. Include detailed manufacturer’s instructions for servicing heat exchangers.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm experienced in manufacturing heat exchangers similar to those indicated for this Project and that have a record of successful in-service performance.

B. ASME Compliance: Fabricate and stamp heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 COORDINATION

A. Coordinate layout and installation of heat exchangers with piping system and adjacent work. Revise locations and elevations to suit field conditions and as approved by Owner’s Representative.

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:

1. Shell-and-Tube Heat Exchangers:
   a. Amtrol Inc.
2.2 RATINGS
A. Maximum Temperature: 375 deg F (190 deg C).
B. Maximum Shell Pressure: 225 psig (1551 kPa).
C. Maximum Tube Pressure: 300 psig (2068 kPa).
D. Heat Exchanger Type: Water to water.
E. Number of Passes: Multipass.

2.3 SHELL-AND-TUBE HEAT EXCHANGERS
A. Shell and Head Materials: Steel shell and fabricated steel head.
B. Tube and Tube Sheet Materials: Seamless copper tubes with steel tube sheets.
C. Piping Connections: Flanged shell fluid entry and threaded shell fluid exit. Flanged head ports.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine elements and surfaces to receive work for compliance with installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of the heat exchanger. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install heat exchangers according to manufacturer’s written instructions.
B. Install heat exchangers plumb and level; anchor with supports.
C. Maintain manufacturer’s recommended clearances for service and maintenance. Install piping connections maintaining clearances for service and maintenance of heat exchangers.
D. Install threaded or flanged connections at heat exchangers.
E. Install shutoff valves at heat exchanger inlet and outlet connections.

3.3 COMMISSIONING
A. Provide services of a factory-authorized service representative to provide startup service.
B. Verify that heat exchanger installation complies with manufacturer’s submittal and installation requirements. Do not proceed with startup until installation is acceptable to manufacturer’s representative.
C. Start heat exchanger according to manufacturer’s instructions.

D. Adjust flows and controls to deliver specified performance.

E. Operate and adjust controls and safeties.

3.4 CLEANING

A. Inspect exposed finish after completing system installation, including pipe connections, fittings, valves, and specialties. Remove burrs, dirt, and construction debris, and repair damaged finishes, including chips, scratches, and abrasions.

3.5 DEMONSTRATION

A. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals.

C. Schedule training with Owner through Architect with at least 7 days’ advance notice.

END OF SECTION
SECTION 236426  NATURAL GAS-FIRED ENGINE DRIVEN CHILLERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes combustion engine-driven indoor water-cooled water chillers with integral factory control panel, combustion exhaust silencer assembly and combustion engine. Major combustion engine components include water circulation pump, engine water thermostat, oil system, acoustic enclosure, and other accessories.

1.2 SUBMITTALS
A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specifications Sections.
B. Product Data for each chiller, including chiller refrigerant, chiller capacity, natural gas input, condenser pressure drop, cooler pressure drop, weights (shipping, installed, and operating), furnished accessories, and electrical characteristics. Include the following:
   1. Dimensioned plan and elevation view Drawings for complete assembly including motor starter cabinet, factory control panel, etc., with required clearances and location of all field connections.
   2. Connected utility requirements: electricity, water, natural gas, etc. Provide quality and quantity for all required utilities.
   3. Schematic drawing of the power and ancillary utility field connection requirements, indicating all furnished items.
   4. Schematic diagram of control system indicating points for field interface/connection.
   5. Manufacturer's custom selection print-out of the performance for each chiller unit. Selection shall indicate, as a minimum, the following:
      a. Selection input data.
      b. Chiller unit model number of the unit.
      c. Net refrigeration capacity (net of any cooling required by aftercoolers or intercoolers).
      d. Power consumption in kW.
      e. Total gas consumption at 100%, 75%, 50%, and 25% load, in MBtu/hr of Higher Heating Value (HHV).
      f. Number of engines operational (if multiple engines per chiller).
      g. Engine horsepower.
      h. Combustion air flow in SCFM.
      i. Exhaust conditions (flows both in units of ACFM and lbs/hr).
      j. Engine emissions levels, after controls (in grams/bhp-hr of NOx, CO, and NMHC).
      k. Engine heat recovery conditions (amount of heat recovery in MBtu/hr, supply and return water temperatures in °F, and heat recovery flow in gpm).
      l. Condenser and evaporator passes.
      m. Condenser and evaporator fouling factor.
      n. Condenser and evaporator, entering and leaving water temperatures.
      o. Condenser water flow in gpm, and pressure drop in feet water.
      p. Evaporator water flow in gpm, and pressure drop in feet water.
      q. Rated load Amp draw.
      r. Engine “dump” heat exchanger flow in gpm and temperature in °F.
s. Overall cooling tower heat rejection requirement in MBtu/hr, including both condenser and engine dump heat exchanger. Also, total flow in gpm and mixed temperature in °F.
t. Outline specification indicating materials and other pertinent information.
u. Shipping and operating weights.
v. Noise levels produced by equipment at full and part loads.

C. Shop Drawings showing fabrication and installation of chillers, including plans, elevations, sections, details of components, attachments, and other construction elements. Include the following:
   1. Dimensions.
   2. Weight loadings and distribution.
   3. Clearances for maintenance and operation.
   4. Size and location of field connections.

D. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.

E. Coordination Drawings showing the following:
   1. Structural supports.
   2. Piping roughing-in requirements.
   4. Access requirements around other work, including working clearances to mechanical controls and electrical equipment.

F. Operation and Maintenance data for each chiller to include in the operation and maintenance manual specified in Division 1.

G. Certification of performance and factory test results specified in “Source Quality Control” Article.

H. Submit chiller factory start-up, testing, and performance certification at integrated part load and application part load in accordance with latest edition of ARI 550.

I. Submit chiller start-up, testing, and performance certification at integrated part load and application part load in accordance with latest edition of ARI 550.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture. Supply all equipment and accessories new, free from defects. All items of a given type shall be the product of the same manufacturer.

B. Chillers shall be fully assembled and factory tested, including a Certified Test Report of the machine capacity and efficiency at 100 percent load per ARI standard 550-2.
   1. Provide one test report per machine.

C. ARI Compliance: Rate chiller according to ARI 550.
D. ASHRAE Compliance: Conform to ASHRAE 15 for chiller design, construction, leak testing, and installation.

E. ANSI Compliance: Conform to ANSI B31.5 for refrigeration piping.

F. ASME Compliance: Comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for construction and testing of evaporator and condenser pressure vessels. Label evaporator and condenser with ASME mark.

G. AGA Compliance: Comply with American Gas Association requirements.

H. NEC Compliance: Comply with applicable NEC requirements for electrical power and control wiring.

I. The chiller shall be UL or ETL listed. Listing shall be in compliance with the Requirements of the Standard for Heat and Cooling Equipment (ANSI/UL-1995) and Performance Protocol Established by AGA Requirements for Gas Fired Engine Driven Air Conditioner Appliance No. 4-89.

J. Refrigerant Exposure: Monitor machine room and sound audible alarm if refrigerant concentrations exceed 10 ppm.

1.3 WARRANTY

A. The special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of Contract Documents.

B. Special Warranty: Submit a written warranty signed by chiller manufacturer and Installer agreeing to furnish parts for compressor and engine failures within special warranty period.
   1. Warranty Period: 5 years from date of Substantial Completion.

C. Warranty to commence after commissioning and complete system acceptance

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Chiller shall be shipped fully assembled and tested, including a Certified Test Report signed by a corporate officer of the machine capacity and efficiency at 100 percent load per ARI standard 550.
   1. Provide test report for each machine.

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. Tecogen Tecochill, Inc.
2.2 NATURAL GAS COMBUSTION ENGINE-DRIVEN WATER CHILLER

A. General Requirements
   1. Furnish and install combustion engine-driven rotary screw compressor-based water chiller having the capacity, features, utility connections/consumption, etc. scheduled on Drawings. Scheduled capacity does not include cooling tons that may be required by engine aftercoolers or intercoolers.
   2. Chiller shall be complete with a single-stage helical rotary screw compressor with variable capacity control, driven by a reciprocating gas combustion engine.
   3. Compressor shall be mounted on a factory-packaged assembly including an evaporator, condenser, interconnecting piping, complete refrigerant and oil charge, and prewired control panel, all as specified below.
      a. All frames, brackets, panels, etc. of ferrous metal shall be shop coated with Amerlock or equivalent.
      b. Exhaust shall not be painted

B. Provide factory packaged and tested natural gas engine-driven liquid chiller. Each microprocessor-controlled chiller shall utilize screw compressor(s), operating with Refrigerant-134a, driven by a rich-burn type natural gas engine.

C. Chiller performance ratings shall be in accordance with ARI Standard 550-92.

2.3 COMBUSTION ENGINE

A. Each chiller’s natural gas engine shall each be of the water-cooled V-style 8-cylinder spark-ignition naturally aspirated type, with:
   1. Jacket suitable for 15 psig.
   2. Crankshaft free of critical vibration within normal operating speeds.
   3. No harmful torsional vibration when driving the compressor at any speed between 0 and 120 percent of maximum operating speed. Provide manufacturer’s vibration isolation between engine mounts and chiller.
   4. Sufficient power to provide the scheduled refrigeration capacity at normal operating speed when supplied with low-pressure natural gas of 1,020 Btu cubic feet at 13 to 28 inches water column.
   5. Remote 55-gallon or larger capacity oil tank for each engine, oil circulation pump, oil level sensor, flex hosing, and low level alarm. Oil sump quantity shall be sufficient to allow a minimum engine oil change interval of 3000 engine run-hours or 1500 equivalent full-load hours, whichever comes first.
   6. Integral engine oil cooler and oil filter(s).
   7. Starting system consisting of 12-volt batteries, starter motor, and battery charger. To minimize the size of the chiller’s electrical connection, electric engine starting systems shall not be allowed.
   8. Engine jacket coolant water pump wired and controlled from within the chiller, factory-installed thermostat control valves for engine warm up and heat recovery, a shell-and-tube “dump” heat exchanger, and an expansion tank (provided loose, for field installation).
   9. Fuel system shall include dual solenoid shut-off valves, gas pressure regulator, carburetor, and throttle body assembly.
2.4 ROTARY SCREW COMPRESSOR

A. Each chiller’s compressor shall be of the single-stage, positive-displacement, open-drive, oil-injected, single rotary screw type, operating at no more than 3600 RPM and featuring an oil separating system, oil sump, and oil filter integral to the chiller.

B. Statically and dynamically balance rotating parts and mount on chiller package.

C. Part-load efficiency and capacity control of the compressor shall be accomplished by decreasing engine speed, with continuous chiller unloading down to manufacturer’s stated minimum.
   1. Capacity reduction shall be of the continuously rebalancing type and shall be fully proportional to the increase or decrease in load. The capacity control shall permit stable operation of the refrigeration system at any point within its capacity reduction range and permit rapid control response to sudden load changes without producing "surging."
   2. Further refrigeration capacity reduction shall be achieved by cycling of a hot gas bypass line.

D. Provide crankcase heater to evaporate refrigerant returning to crankcase during shut down. Energize heater when compressor is not operating.

2.5 EVAPORATOR

A. Provide evaporator of shell-and-tube flooded type, seamless or welded steel construction with cast iron or fabricated steel heads, high-efficiency seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets and individually replaceable.

B. Design, test, and stamp refrigerant side for 225 psig working pressure and water side for 150 psig working pressure, in accordance with ANSI/ASME Section 8.

C. Provide factory applied flexible elastomeric insulation.

D. Provide refrigerant relief valve on shell side of the vessel.

E. Provide water-side vent and drain connection on each end bell of the vessel.

F. Provide with Victaulic connections.

2.6 CONDENSER

A. Provide condenser of shell-and-tube type, seamless or welded steel construction with cast-iron or fabricated steel heads, high-efficiency seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets and individually replaceable.

B. Design, test, and stamp refrigerant side for 250 psig working pressure in accordance with ANSI/ASME Section 8.

C. Provide 250 psig safety dual relief valve on condenser shell.
D. Design, test, and stamp water side for 150 psig working pressure in accordance with ASME Pressure Vessel Code

E. Provide water-side vent and drain connection on each end bell of the vessel.

F. Provide with Victaulic connections.

G. Vessel shall be cleanable.

2.7 REFRIGERANT CIRCUIT

A. Provide refrigerant circuits, factory supplied and piped.

B. Vent Pipe: Provide black steel vent pipe from rupture disk to exterior of building.

C. Chiller shall be provided with a microprocessor-based metering valve for regulating refrigerant flow from the condenser to the evaporator, in order to maintain the proper amount of liquid in each of the heat exchangers under both full- and part-load conditions.

D. The chiller’s microprocessor shall interface with a digitally controlled stepper motor operator on the metering valve, to provide control of small incremental movements of the valve stem.

E. Provide for the refrigerant circuit:
   1. Liquid line sight glass and moisture indicator.
   2. Thermal expansion for maximum operating pressure.
   3. Charging valve.
   4. Insulated suction line.
   5. Discharge line check valve.
   6. Compressor discharge service valve.
   7. Pressure relief device (rupture disc).

2.8 CONTROLS

A. Steel control panel minimum NEMA-3 rating shall be factory mounted, wired and configured on each chiller. Panel shall contain power and control wiring and be factory-wired with a single-point power connection.

B. Chiller panel shall house both chiller and engine controls; separate chiller and engine panels shall not be allowed.

C. The chiller shall be furnished with an electronic microprocessor-based control system including the microprocessor, power supplies, a digital I/O board with relays, an analog sensor board including sensors, a 2-line 40-character alpha-numeric display, start/stop keys, status lights, reset buttons, function keys, an emergency stop pushbutton, an engine overspeed device, a modem for remote communications, and related mechanical relays and wiring.

D. Startup and shutdown of the machine shall be manual or automatic. Automatic operation shall be activated by a switched input from the Owner’s BAS to the control panel.

E. Chilled water setpoint (adjustable) shall be manually entered at the control panel or input to the system with a varying signal from a building management system.
F. The chiller control panel shall be able to provide output signals to start/stop the chilled water pumps, start/stop the condenser water pumps, and indicate chiller alarm.

G. The chiller control panel shall be able to accept an input signal from field mounted flow switch to prove/confirm flow in the chilled water loop before starting. Signal shall come from an external flow switch or differential pressure-type switch that is provided by chiller manufacturer for field installation, wiring and configuration.

H. The chiller factory control panel shall be equipped with a standalone control system which shall allow monitoring and limited control of the unit from a remote site through either a customer’s analog phoneline interface or via a network connection. Network connection shall use the BACnet protocol for communication to the building automation system operator workstation or web server and for communication.

I. The factory controller shall have the option of controlling the chilled water return temperature rather than the supply temperature.

J. The factory controller shall be capable of restarting the unit automatically 15 minutes after power is restored following an outage.

K. The factory controller shall be capable of cycling the chiller when it operates below 40 percent capacity for an extended period of time in order to facilitate oil return.

L. The following functions shall be available from the factory control panel at a minimum:
   1. Start chiller.
   2. Stop chiller (normal and emergency).
   3. Adjust chilled water setpoint.
   4. Adjust maximum engine speed setting.
   5. Clear alarms.
   7. Schedule Start/Stop Sequence.
   8. Schedule chilled water setpoint.
   9. Set time and date.
  10. Energize individual outputs for diagnostics.
  12. Calibrate analog card.
  13. Change control gains.
  15. Change remote setpoint input signal range.

M. The following information shall be available from the factory control panel display:
   1. Chilled water outlet temperature.
   2. Chilled water setpoint.
   3. Engine rpm.
   4. Runtime.
   5. EFLH.
   7. Average load.
   8. Maximum speed setting.
  10. Discharge temperature.
  11. Compressor oil temperature.
15. Discharge pressure.
16. Compressor oil pressure.
17. Oil filter pressure drop.
18. Last 20 alarms.
19. Date and time.

N. The sequence of operations shall initiate with a pump start sequence, followed by the engine start, engine warm-up, engine speed ramp-up, and then setpoint control. Normal shutdowns shall occur with a gradual engine speed rampdown followed by compressor unloading. After the engine stops, pumps shall be circulated for a short time afterward.

O. Setpoint control shall be achieved by modulating engine speed in a range of 1,000 RPM to 3,600 RPM.

P. Engine speed control shall be achieved through the use of a stepper motor driving the throttle linkage. This allows the chilled water setpoint to be maintained to within one half of a degree from setpoint eliminating hunting and decreasing part load energy consumption.

2.9 SAFETIES AND DIAGNOSTICS

A. The factory controller shall automatically shut down the chiller when one of the following alarms occur (listed as displayed):
   1. Engine Oil Level (low or high)
   2. Evaporator Pump Fail
   3. Hi Accel Time
   4. High Compressor Oil Temperature
   5. High Coolant Temperature
   6. High Discharge Pressure
   7. High Discharge Temperature
   8. Keypad Failure
   9. Low Chiller Temperature
   10. Low Compressor Oil Pressure
   11. Low Compressor Oil Temperature
   12. Low Coolant Pressure
   13. Low Coolant Temperature
   14. Low Eng Oil Pressure
   15. Low Suction Pressure
   16. Overspeed
   17. Processor Error
   18. Start Failure
   19. Starter Failure
   20. Analog Card Failure
   21. Ignition Power Failure
   22. Underspeed
   23. Low Compressor Oil Level
   24. Low Injection Oil Pressure
   25. High Coolant Pressure
   26. High Enclosure Temperature
   27. High Engine Oil Temperature
28. Engine Emission Failure
29. High Catalyst Temperature

B. The factory controller shall take corrective action by reducing capacity when it is detected that the system is approaching one of the following alarms:
   1. High Discharge Pressure
   2. High Coolant Pressure
   3. Low Compressor Oil Press
   4. Low Suction Pressure
   5. High Engine Oil Temperature

   Once the condition is within acceptable limits, the system shall resume normal operation.

C. The factory controller shall include a diagnostic mode which allows all output devices to be energized individually when the system is shutdown for the purpose of troubleshooting. These outputs include pumps, solenoids, heaters, and relays. Also, the status of input switches shall be accessible in this mode.

D. The factory controller shall be equipped with a redundant engine overspeed safety device independent of the microprocessor which shall interrupt power to the gas solenoid when it senses an overspeed.

2.10 EMISSIONS CONTROL SYSTEM

A. The chiller shall be equipped with an emissions control system for each engine that reduces engine exhaust emissions to not more than 0.5 grams NOx/ Bhp-hr, 1.0 grams CO/ Bhp-hr, and 0.15 grams NMHC/ Bhp-hr to comply with local DEP requirements (air permitting is by others).

B. Emissions system shall also include a microprocessor-based air/fuel ratio controller, integral to the chiller.

C. The emissions system controller shall be capable of relaying key emissions system operating parameters to a remote user, via modem and phoneline or internet. This data shall be accessible through the chiller’s microprocessor panel and remote monitoring and control system, rather than through a separate phoneline interface.

D. Emissions system shall be furnished with leaving overtemperature protection.

2.11 ACOUSTICAL ENCLOSURE AND PERFORMANCE

A. Provide a lined acoustic enclosure over each engine and compressor to reduce emitted noise. Sound pressure levels for the complete unit shall not exceed 86 dBA at full-load, as measured at 1 meter, free-field, excluding wall-reflected noise. Sound data shall be measured in accordance with ARI Standard 575. Each acoustic enclosure shall have easily removable panels for servicing. Each enclosure shall be equipped with a ventilation fan that is powered and controlled internally from each chiller’s microprocessor control panel.

2.12 FULL HEAT RECOVERY

A. The chiller shall be provided with engine jacket heat recovery and integral exhaust gas heat recovery, and shall be capable of supplying scheduled heat recovery, at full-load operation.
2.13 EXHAUST SILENCER
A. Each chiller shall be furnished with flanged, Critical-grade stainless-steel exhaust silencer(s) as required. Silencer(s) shall be provided loose with all required accessories and hardware, for field installation in the exhaust piping.

2.14 EXHAUST THERMAL EXPANSION JOINT
A. Each chiller shall be furnished with flanged exhaust thermal expansion joint(s) for each engine. Thermal expansion joint shall provide for axial compression of up to 3 inches in the exhaust piping. Thermal expansion joint shall be provided loose with all required accessories and hardware, for field installation in the exhaust piping.

2.15 ENGINE MAKE-UP WATER EXPANSION TANK
A. Each chiller shall be furnished with an Amtrol Fill-Trol pre-pressurized, diaphragm-type expansion tank, sized by chiller manufacturer, with automatic pressure reducing valve. Provide line sized reduced pressure zone (RPZ) backflow preventer in cold water line. Tank assembly shall be provided with all required accessories and hardware for field installation in the chiller’s make-up water line.

2.16 TESTS
A. Each fully assembled chiller shall undergo a factory run-test at full capacity to ensure proper set-up and operation of all components. Written certification shall be provided to the Owner.
B. Testing of partial chiller assemblies, or field testing in lieu of factory run-testing, shall not be permitted.
C. Each fully assembled chiller package shall be leak tested with dry nitrogen to 200 psi using nitrogen detectors. After leak testing, the package shall be evacuated and charged with a full charge of R-134a for shipment.
D. The electrical system shall undergo a dielectric withstand test to 1200 volts for 1 second.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Verify that surfaces are ready to receive work and field dimensions are shown on Drawings.
B. Verify that required utilities are available in proper size and location and are ready for use.
C. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION
A. Install in accordance with manufacturer's instructions.
B. Provide for connection to electrical service. Refer to Specification, Electrical Requirements for Mechanical Equipment.
1. Supply single-phase power to the unit at the voltage and frequency listed in the equipment schedule.
2. Supply and install the main electrical power line, disconnect switches, circuit breakers, and electrical protection devices per local code requirements.
3. Wire flow switch(s) from the chilled water circuit to the chiller control circuit, to ensure water flow is present during chiller operation.
4. Wire the chilled water pumps and condenser water pumps circuits to the chiller output relays.
5. Provide wiring and any devices necessary to interface the chiller with the building control system to start/stop the unit, control the chilled water setpoint, or to receive an alarm output.

C. Install each chiller on a concrete pad with neoprene-type isolator pads and set unit level. Anchor chiller to concrete pad.

D. Provide connection to chilled water piping. On inlet, provide thermometer well for temperature controller, thermometer, strainer, differential pressure-type flow switch, flexible pipe connector, pressure gage, shut-off butterfly valve. On outlet, provide thermometer, flexible pipe connector, pressure gage, shut-off and balancing butterfly valve.

E. Provide connection to condenser water piping. On inlet, provide thermometer well for temperature limit controller, thermometer, strainer, flexible pipe connector, pressure gage, shut-off butterfly valve. On outlet, provide thermometer, flexible pipe connector, pressure gage, and shut-off and balancing butterfly valve.

F. Provide connections between each chiller’s dump heat exchanger and condenser water piping.

G. Provide engine make-up water connection to each chiller, including expansion tank, pressure reducing valve and reduced pressure zone principle backflow preventer (line sized).

H. Provide connection from chiller’s engine coolant relief valve to drain, per code.

I. Provide water connections from chiller for engine heat recovery to remote heat recovery heat exchanger(s).

J. Arrange piping for easy dismantling to permit tube cleaning.

K. Provide piping from chiller refrigerant safety relief valves or rupture relief discs to outdoors. Size piping and route to exterior discharge point per code. Size piping as recommended by chiller manufacturer, and terminate with gooseneck facing down.

L. Provide for installation of gas piping to each chiller, including pressure regulator, strainer, shut-off valve, and dirt leg trap, per code.

M. Provide for installation of insulated stainless exhaust piping from each chiller, including catalytic converter, silencer, thermal expansion joints, rigid anchors, pipe guides, roller hangers, and saddles, per code.

N. Install and pipe the engine bulk oil system per manufacturer requirement.

O. Prior to chiller manufacturer’s start-up services, contractor shall confirm that each chiller is ready for start-up, including verification that all connections are made, flows and pressures
checked, leaks checked, air removed, instrumentation installed, etc. Contractor shall assist the manufacturer’s service technician during start-up.

3.3 MANUFACTURER’S FIELD SERVICES

A. Engage a factory-authorized service representative to perform startup service. Chiller manufacturer’s start-up service shall include:

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify gas utility pressure, makeup water pressure, and electrical power connections.
4. Verify that pumps are installed and functional.
5. Verify that thermometers and gages are installed.
6. Verify chilled water flow safety/proving switch installed and wired.
7. Verify refrigerant charge, engine pan oil level, and compressor oil in each chiller
8. Verify installation of bulk oil system for each engine, including 55-gallon reservoir, circulating pump, and connecting hoses.
9. Operation and set-up of each engine.
10. Verify that phoneline and modem, and/or building automation system network connection are working properly, and downloading of updated software via modem as necessary.
11. Pre-start check of chiller controller functions.
12. Operate chiller for run-in period at various loads, and verification that operating parameters are within specifications.
13. Check bearing lubrication and oil levels.
14. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
15. Verify proper motor rotation.
16. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
17. Verify and record performance of all key data, including but not limited to fluid flow and low-temperature interlocks for evaporator, condenser, and dump heat exchangers.
19. Test and adjust controls and safety. Replace damaged or malfunctioning controls and equipment as required.
20. Submit inspection, startup, testing and commissioning reports.

B. Demonstrate system operations and verify specified performance.

C. Chiller manufacturer shall assist the Owner during the air emissions source-testing and permitting process.

3.4 DEMONSTRATION

A. Startup Services: Engage a factory-authorized service representative to demonstrate chiller operation and train Owner’s maintenance personnel as specified below.

1. Train Owner’s maintenance personnel on procedures and schedules related to startup, shutdown, troubleshooting, servicing, and preventive maintenance.
2. Review data in the operation and maintenance manuals. Refer to Division 1 Section “Operation and Maintenance Data.”

3. Schedule training with Owner with at least 7 days’ advance notice.

END OF SECTION
SECTION 236513 FACTORY-FABRICATED COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Types of factory-fabricated cooling towers specified in this section include the following:
   1. Induced-draft, propeller fan, counterflow.

1.2 SUBMITTALS

A. Product Data for each cooling tower, including rated capacities, pressure drop, fan performance data, rating curves with design performance indicated, furnished specialties, weights (shipping, installed, and operating), provided accessories and electrical characteristics.
   1. Maximum flow rate.
   3. Drift loss as percent of design flow rate.
   4. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
   5. Performance curves for the following:
      a. Varying entering-water temperatures from design to minimum.
      b. Varying ambient wet-bulb temperatures from design to minimum.
      c. Varying water flow rates from design to minimum.
      d. Varying fan operation (off, minimum, and design speed).
   6. Fan airflow, brake horsepower, and drive losses.
   7. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
   8. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings detailing fabrication and installation of cooling towers, including plans, elevations, sections, component details, attachments, and other construction elements. Include the following:
   1. Dimensions.
   2. Weight loadings and distribution.
   3. Clearances for maintenance and operation.
   4. Size and location of field connections.

C. Wiring diagrams detailing power and control wiring. Differentiate clearly between manufacturer-installed wiring and field-installed wiring.

D. Coordination drawings indicating the following:
   1. Structural supports.
   2. Piping rough-in requirements.
   4. Access requirements around other work, including working clearances to mechanical controls and electrical equipment.

E. Maintenance data for each cooling tower to include in the operating and maintenance manual.

F. Certifications: Submit required certifications and written tests results for required testing.
1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of factory-fabricated cooling towers, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Provide manufacturer’s certification of tower cooling capacity, based on factory-performance tests, and provide performance curve plotting Leaving-Water Temperature (LWT) against Wet-Bulb Temperature (WBT).

C. Regulatory Requirements:
   1. UL and NEMA Compliance: Provide electric motors and electrical components required as part of factory-fabricated cooling towers, which have been listed and labeled by UL and comply with NEMA Standards.
   2. NEC Compliance: Install cooling towers in accordance with NFPA 70 “National Electrical Code.”

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Baltimore Aircoil Co., Inc.

B. Evapco Inc.

C. Marley (The) Cooling Tower Co.

2.2 FACTORY-FABRICATED COOLING TOWERS

A. General: Fabricate cooling towers using manufacturer’s standard design, materials, and construction in accordance with published product information, except as otherwise indicated.

B. Design structural system for the following live loading in addition to tower dead-loads and operating-loads:
   1. Wind Loading: 30 psf on exposed vertical surfaces.

C. Fabricate structural system including assembly of collecting basin and steel casings by one of the following methods:
   1. Bolt connections with fasteners having equal or better corrosion-resistance than materials fastened; seal joints to make watertight enclosure.
   2. Weld connections and weld metal seams continuously to make watertight.
   3. Provide rigging supports on structure for final rigging.

D. Casings: One of the following materials fabricated and installed by manufacturer to make tower watertight:
   1. Provide hot-dipped galvanized steel with polymer coating.
E. Collecting Basin and Sump: One of the following materials and types of units, designed and installed to support water and to ensure water tightness:

1. Provide stainless steel.
2. Provide integral type collecting basin and sump with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow and water make-up.

F. Wetted-Surface Fill: One of the following materials fabricated into wave-formed configurations installed by manufacturer to assure break-up of water into droplets:

1. Provide hot-dipped galvanized steel sheets with polymer coating.

G. Drift Eliminators: One of the following materials fabricated by manufacturer into three-pass configuration to limit drift-loss to indicated maximum percentage of circulating-water flow-rate:

1. Provide hot-dipped galvanized steel with polymer coating.

H. Louvers: One of the following materials designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging:

1. Provide hot-dipped galvanized steel with polymer coating.

I. Water Distribution System: One of the following materials designed and installed by manufacturer to ensure even distribution of water over wetted-surface-fill.

1. Galvanized steel pipe header and removable galvanized steel pipe branches.
2. Nozzles: Provide removable plastic, brass, or ceramic nozzles.
3. Pressure Drop: Maximum pressure drop of 5 psi.

J. Basin Covers: One of the following materials, removable and with handles, installed by manufacturer to prevent debris from entering the basin and to inhibit algae growth by eliminating sunlight:

1. Provide hot-dipped galvanized steel with polymer coating.

K. Inlet Screens: One of the following materials, mounted in removable frames by manufacturer:

1. Provide stainless steel mesh.

L. Handrails: Provide galvanized steel pipe rails of required height above tower. Include knee and toe rails of required diameter and heights.

M. Ladders: Provide galvanized steel or aluminum ladder, to top of cooling tower working surface.


N. Water Level Control: Provide plastic or bronze mechanical float with adjustable linkage.

O. Water Level Control: Provide electric float switch.

P. Water Level Control: Provide electric float switch and solenoid makeup valve.
2.3

A. Flow Control Valves: Provide one of the following flow control valves for balancing flow to each distribution basin, and for shut-off during servicing:

1. Provide butterfly valves.

B. Fans and Drives: Provide one of the following fans and drives, installed by manufacturer.

1. Provide fiberglass reinforced plastic (FRP) propeller fan of fixed-pitch type with low sound option.
   a. Provide gear-drive including speed reducer.
   b. Provide V-belt drives with sheave sized for rated air flow.

C. Fans and Drives: Provide forward curved centrifugal fans with galvanized steel blades and V-belt drive with sheave sized for rated air flow.

D. Fan Bearings: One of the following types installed by manufacturer.

1. Provide self-aligning ball bearings; include external extended grease lines, and fittings.
2. Provide bronze sleeve bearings with external oil lines, and fittings.

E. Motor Type: Provide totally enclosed, fan-cooled energy premium efficient type motor.

F. Motor Speed: Provide inverter duty rated motor suitable for use with a variable speed drive.

G. Vibration Cutout Switch: Provide switch to de-energize fan motors if excessive vibration occurs due to fan imbalance.

H. Discharge Damper Controls: Provide electric damper operator, controller, end switches, transformer, and weatherproof enclosure.

I. Assemble components by one of the following methods:

1. Use galvanized or stainless fasteners and accessories to assemble components.
2. Weld metal seams and joints.

J. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline-soluble rust preventative compound on ferrous parts which cannot be galvanized, including shafts and machined parts.

1. Finish components with zinc-coated metal surfaces by one of the following methods:
   a. Coat abraded areas and welded areas with galvanizing repair paint. Finish-paint exposed surfaces with zinc chromatized paint.
   b. Provide 2-1/4 oz. (per sq. ft. of sheet) zinc coating on basin and sump, after fabrication, by hot-dip galvanizing process. Coat abraded areas and welded areas of work with galvanizing repair paint.
   c. Apply to metal surfaces not galvanized, zinc-rich paint which has been tested and accepted by U.L. as being equivalent to hot-dipped galvanized steel.

K. Maximum Permissible Sound Pressure Level: Use 0.0002 microbar as reference. Measure at 50' in
several directions, uniformly covering 360 degrees. Do not exceed maximum permissible dB level, each of the following octave bands:

1. 63 hz - dB
2. 125 hz - dB
3. 250 hz - dB
4. 500 hz - dB
5. 1000 hz - dB
6. 2000 hz - dB
7. 4000 hz - dB
8. 8000 hz - dB

L. Vibration Control: Provide vibration isolators, with number and size of isolators selected by manufacturer.

1. Isolator Type 4: Restrained spring isolator.

PART 3 - EXECUTION

3.1 GENERAL

A. General: Install cooling towers where indicated, in accordance with equipment manufacturer’s written instructions and with recognized industry practices, to ensure that cooling towers comply with requirements and serve intended purposes.

B. Access: Provide access and service space around and over cooling towers as indicated, but in no case less than that recommended by manufacturer. Coordinate access platform locations and tower orientation for roof conditions (if applicable), adjacent equipment and fall protection requirements.

C. Support: Install cooling tower units on field constructed structural steel framing mechanical equipment stand. Anchor cooling tower to stand with removable fasteners.

1. Field construct mechanical equipment stand as indicated.

D. Placement: Mount unit on vibration isolators. Install gaskets or sealants between cooling tower cells. Level units to tolerance of 1/8" in 10'-0", in both directions.

E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer’s submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to manufacturer and equipment installer.

F. Controls: Install automatic temperature control field-devices per manufacturer’s requirements and specifications.

3.2 ADJUSTING AND CLEANING

A. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer’s touch-up paint.

B. Start-up: Comply with manufacturer’s instructions for filling and start-up of operation, but not less than the following:
1. Verify lubrication of rotating parts; lubricate as needed.
2. Verify fan rotation direction.
3. Verify that motor amperage is in accordance with manufacturer’s data.
4. Balance condenser water flow to each tower, and to each inlet for multiple inlet towers.
5. Adjust water level control for proper operating level.
6. Adjust bleed valve for indicated percentage of circulated water volume.
7. Balance equalizer lines between multiple towers (if any).
8. Adjust temperature controls and verify operation.

C. Operation Test: Test each cooling tower to show that it will operate in accordance with indicated requirements.

D. Passivation Treatment: Provide Passivation Treatment of the cooling tower in accordance with the manufacturer’s written recommendations.

3.3 CLOSEOUT PROCEDURES

A. Provide services of manufacturer’s technical representative for one 8-hour day to instruct Owner’s personnel in operation and maintenance of factory-fabricated cooling towers.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.4 SPARE PARTS

A. General: Furnish to Owner, with receipt, the following spare parts:

1. One spare set of matched fan belts for each belt driven fan.
2. Three spare spray nozzles for each tower cell.
3. One spare gasket for each gasketed access and inspection opening.
4. One valve seat for mechanical water make-up valve.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes variable-volume, central-station air-handling units with coils for indoor installations.

1.2 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each central-station air-handling unit specified, including the following:
   1. Certified fan-performance curves with system operating conditions indicated.
   2. Certified fan-sound power ratings.
   3. Certified coil-performance ratings with system operating conditions indicated.
   4. Motor ratings and electrical characteristics plus motor and fan accessories.
   5. Material gages and finishes.
   6. Filters with performance characteristics.
   7. Dampers, including housings, linkages, and operators.

C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.

E. Coordination Drawings, including floor plans and sections drawn to scale. Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

F. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

G. Maintenance data for central-station air-handling units to include in the operation and maintenance manual.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Central-station air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, “Installation of Air Conditioning and Ventilating Systems.”

B. UL Compliance: Central-station air-handling unit, shall be listed and labeled by UL.

C. ARI Certification: Central-station air-handling units and their components shall be factory tested according to the applicable portions of ARI 430, “Central-Station Air-Handling Units,” and shall be listed and bear the label of the Air-Conditioning and Refrigeration Institute (ARI).
D. UL and NEMA Compliance: Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards.

E. Comply with NFPA 70 for components and installation.

F. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The Terms “Listed” and “Labeled”: As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

G. Coordination: Coordinate layout and installation of central-station air-handling units with piping and ductwork and with other installations.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver air-handling unit as a factory-assembled module with protective crating and covering.

B. Lift and support units with manufacturer’s designated lifting or supporting points.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate size and location of concrete housekeeping bases. Cast anchor-bolt inserts into base.

B. Coordinate size and location of structural-steel support members.

1.6 EXTRA MATERIALS

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

B. Filters: Furnish 1 set for each central-station air-handling unit.

C. Fan Belts: Furnish 1 set for each central-station air-handling unit fan.

D. Gaskets: Furnish 1 for each sectional joint of each central-station air-handling unit.

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. Airtherm Manufacturing Company.

2. Buffalo Forge Co.

3. Carrier Corp.; Carrier Air Conditioning Div.

4. Coil Co., Inc.

5. Dunham-Bush, Inc.

6. Engineered Air.
7. Mammoth, Inc.
8. Miller-Picking Corp.
10. Trane Company (The); Commercial Systems Group.
11. USA Coil & Air Inc.
13. McQuay.

2.2 MANUFACTURED UNITS

A. General Description: Factory assembled, consisting of fans, motor and drive assembly, coils, dampers, plenums, filters, drip pans, mixing boxes, mixing dampers and access sections.

2.3 CABINET

A. Materials: Formed and reinforced galvanized steel panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
   1. Outside Casing: Galvanized steel, 0.0635 inch (1.61 mm).
   2. Inside Casing: Galvanized steel, 0.0276 inch (0.7 mm).
   3. Floor Plate: Galvanized steel, 0.1382 inch (3.5 mm).

   1. Thickness: 2 inches (50 mm).
   2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from and including the cooling coil section.

C. Access Panels and Doors: Same materials and finishes as cabinet and complete with hinges, latches, handles, and gaskets.
   1. Fan section shall have inspection and access panels and doors sized and located to allow periodic maintenance and inspections.

D. Drain Pans: Formed sections of stainless steel sheet. Fabricate pans in sizes and shapes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
   1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
   2. Drain Connections: Both ends of pan.
   4. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

2.4 FAN SECTION

A. Fan-Section Construction: Belt-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure, equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan scroll, wheel,
shaft, bearings, and motor on structural-steel frame, with frame mounted on base with vibration isolation.

B. Housings: Fabricate from formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.

C. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor power. Fan wheel shall be double-width, double-inlet type with forward-curved blades or backward-curved airfoil blades as indicated.

1. Plug Fans: Fabricate without fan scroll and volute housing, with steel cabinet.
2. Backward Inclined: Steel or aluminum construction with curved inlet flange, back plate, backward-curved blades, and cast-iron or cast-steel hub.
3. Forward Curved: Black steel with enamel or galvanized finish, and having an inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, and steel hub.
4. Airfoil Wheel: Steel; with smooth, curved inlet flange; back plate; die-formed, hollow, airfoil blades; and cast-iron or cast-steel hub.
5. Shafts: Hot-rolled steel; turned, ground, and polished, and having keyway to secure to fan wheel hub.
6. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball or roller bearings with the following:
   a. Rated Bearing Life: ABMA 9 or ABMA 11, L-50 of 400,000 hours.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor: 1.5.
8. Pulleys: Cast iron or steel with split, tapered bushing, dynamically balanced at factory.
9. Motor Pulleys: Adjustable pitch, selected so pitch adjustment is at middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.
11. Belt Guards: Fabricate to OSHA/SMACNA requirements, 0.1046 inch (2.7 mm) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated.
   a. Provide belt guards for motors mounted on outside of cabinet.
13. Accessories: Provide the following:
   a. Discharge dampers.
14. Vibration Control: Install fans on housed-spring vibration isolators, minimum 1-inch (25-mm) static deflection, with side snubbers.
D. Fan-Section Source Quality Control: The following factory tests are required.


2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, “Laboratory Methods of Testing Fans for Rating.”

2.5 MOTORS

A. General: Refer to Division 15 Section “Motors” for general requirements.

B. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.

C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.

D. Temperature Rating: 50°C maximum temperature rise at 40°C ambient for continuous duty at full load (Class A Insulation).

E. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

F. Motor Construction: NEMA MG-1, general purpose, continuous duty, Design B.


G. Bearings: The following features are required:

1. Ball or roller bearings with inner and outer shaft seals.

2. Grease lubricated.

3. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

H. Enclosure Type: The following features are required:

1. Open dripproof motors where satisfactorily housed or remotely located during operation.

2. Guarded dripproof motors where exposed to contact by employees or building occupants.

I. Overload Protection: Built-in, automatic reset, thermal overload protection.


K. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled according to IEEE 112, Test Method B. If efficiency is not specified, motors shall have a higher efficiency than “average standard industry motors” according to IEEE 112, Test Method B.

L. Nameplate: Indicate full identification of manufacturer, ratings, characteristics, construction, and special features.
M. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in other Sections.

2.6 COILS

A. Coil Sections: Common or individual, insulated, galvanized steel casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils.

B. Coil Construction: Rigidly supported across full face, pitched to allow drainage.

1. Fins: Aluminum, mechanically bonded to tubes.

2. Tubes: Seamless copper.


4. Headers for Water Coils: Steel, cast iron, or copper with connections for drain valve and air vent, and threaded piping connections.

C. Water Coils: Drainable with threaded plugs, serpentine with return bends in smaller sizes and with return headers in larger sizes.


2.7 DAMPERS

A. General: Leakage rate, according to AMCA 500, “Test Methods for Louvers, Dampers and Shutters,” shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.

1. Damper operators shall be electrically operated.

B. Face and Bypass Dampers: Opposed-blade galvanized steel dampers, with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized steel frame, and with operating rods connected together with a common linkage. Break-form damper blades, provide gaskets and edge seals, and mechanically fasten to operating rod.

C. Combination Filter/Mixing Box: Parallel-blade galvanized steel damper blades mechanically fastened to steel operating rod in reinforced, galvanized steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat permanent or throwaway filters. Provide hinged access panels or doors to allow removal of filters from both sides of unit.

2.8 FILTER SECTION

A. Filters: Comply with NFPA 90A.

B. Filter Section: Provide filter media holding frames arranged for flat or angular orientation, with access doors on both sides of unit.

C. Permanent Filters: Cleanable, 2 inches (50 mm) thick, with aluminum- or stainless-steel media and stainless-steel frames, clean airflow resistance of 0.10 inch wg (25 Pa) at face velocity of 500 fpm (2.54 m/s), and ASHRAE 52.1 filter-arrestance efficiency of 60 to 80 percent.
D. Disposable Filters: 2-inch- (50-mm-) thick, viscous-coated fibers encased in fiberboard cell with perforated-metal media support, clean airflow resistance of 0.10 inch wg (25 Pa) at face velocity of 300 fpm (1.52 m/s) and ASHRAE 52.1 filter-arrestance efficiency of 70 to 82 percent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions to receive equipment, for compliance with installation tolerances and other conditions affecting performance of central-station air-handling units.

B. Examine roughing-in of steam, hydronic, condensate drainage piping, and electrical to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Install central-station air-handling units level and plumb, according to manufacturer’s written instructions.


B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

3.3 HOUSEKEEPING BASES

A. Coordinate size of housekeeping bases with actual unit sizes provided. Construct base 6 inches (150 mm) larger in both directions than overall dimensions of supported unit.

B. Form concrete bases with framing lumber with form-release compounds. Chamfer top edge and corners of base.

C. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.

D. Place concrete and allow to cure before installing units. Use portland cement conforming to ASTM C 150, 4000-psig (27.6-MPa) compressive strength, and normal-weight aggregate.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

   1. Install piping adjacent to machine to allow service and maintenance.

   2. Connection piping to air-handling units with flexible connectors.

   3. Connect condensate drain pans using minimum 1-1/4-inch NPS (DN32), Type M copper
tubing, or sized as indicated elsewhere. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

4. **Hot- and Chilled-Water Piping**: Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.

**B. Duct installation and connection requirements are specified in other Sections. The Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.**

**C. Electrical**: Conform to applicable requirements of other Sections.

1. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

2. Temperature control wiring and interlock wiring is specified in other Sections.

### 3.5 ADJUSTING

**A.** Adjust damper linkages for proper damper operation.

### 3.6 CLEANING

**A.** After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

**B.** Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

### 3.7 COMMISSIONING

**A.** Manufacturer’s Field Inspection: Engage a factory-authorized service representative to perform the following:

1. Inspect field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.

2. Prepare a written report on findings and recommended corrective actions.

**B.** Final Checks before Startup: Perform the following before startup:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Set face-and-bypass dampers to full face flow.

7. Set outside-air and return-air mixing dampers to minimum outside-air setting.


9. Install clean filters.

10. Verify that manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in fully open position.

C. Starting procedures for central-station air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
   a. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to other Sections for air-handling system testing, adjusting, and balancing.

3.8 DEMONSTRATION

A. Engage the services of a factory-authorized service representative to train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

1. Review data in the operation and maintenance manuals.

2. Schedule training with Owner, through Architect, with at least 7 days’ advance notice.

END OF SECTION
SECTION 237423 GAS FIRED HEATING AND VENTILATION UNIT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gas fired heating and ventilation units.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer’s technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings:

1. Submit shop drawings detailing the manufacturer’s electrical requirements for power supply wiring for gas fired make-up air units. Submit manufacturer’s ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

2. Submit shop drawings detailing the mounting, securing, and flashing of the roof curb to the roof structure. Indicate coordinating requirements with roof membrane system.

C. Operation and Maintenance Data: Submit maintenance data and parts list for each rooftop unit, including “trouble-shooting” maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of gas fired make-up air units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Regulatory Requirements:

1. Gas-fired furnace section construction shall be in accordance with AGA safety standards. Furnace section shall bear the AGA label.

2. Comply with ARI 440 for testing and rating units.

3. Comply with NFPA 70 for components and installation.

4. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

   a. The Terms “Listed” and “Labeled”: As defined in the National Electrical Code, Article 100.

   b. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

1.4 MAINTENANCE

A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each unit:

   1. One set of matched fan belts for each belt-driven fan.

   2. One set filters for each unit.
PART 2 - PRODUCTS

2.1 GAS FIRED HEATING AND VENTILATION UNITS

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:
   1. ABB Aerovent Inc.
   2. Nesbitt.
   4. The Trane Co.
   5. Greenheck

B. Provide packaged, heating and ventilation units designed for 80% thermal efficiency with gravity-vented gas furnaces, arranged for indoor mounting suspended from building structure. Arrange for field duct connection with horizontal supply connection at discharge and horizontal inlet connection for outside air.

C. The units are to include a centrifugal blower, open drip-proof, energy efficient, blower motor, and an adjustable belt drive, filter rack with 2" disposable filters, factory installed. Include all required controls, dampers, and inlets to provide an air control cycle with full cabinet insulation.

D. All units shall be equipped for use with natural gas, 24-volt control transformer, gravity vent caps, motor starter, intermittent spark pilot, and (3) stage gas control.

E. The gas furnaces shall be direct fired burner in the air stream with die-formed burners of 409 stainless steel and 409 stainless steel drip pan.

F. The following accessories shall be provided:
   1. Firestat outlet.
   2. Convenience.
   3. Downturn plenum.
   4. IRI manifold.
   5. Gas pressure safety switches.
   6. Full perimeter curb.
   7. Disconnect switch.
   8. Electronic 7-day programmable thermostat.
   9. 100% outdoor air hood.
   10. 100% outdoor air and 100% return inlets with dampers, independent modulating damper motors and remote static pressure sensor to control damper settings.
   11. Manufacturer's housed spring isolators.
12. Overcurrent protection fuses.
14. Heat-dissipation switch keeps fans running when unit discharge temperature rises above 100 degF (38 degC).

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

A. General: Install units in accordance with manufacturer’s installation instructions and NFPA 90A. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer’s recommended clearances.

B. Support: Install and secure unit supports from building structure in accordance with manufacturer's installation recommendations and shop drawings. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing.

C. Electrical Connections: Final connections to equipment and installation of loose shipped electrical components are specified elsewhere.

3.3 DEMONSTRATION

A. Start-Up Services:

1. Provide the services of a factory-authorized service representative to start-up units, in accordance with manufacturer’s written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

2. Replace filters.

B. Operating and Maintenance Training:

1. Provide services of manufacturer's service representative to instruct Owner’s personnel in operation and maintenance of units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.

   a. Schedule training with Owner, provide at least 7-day prior notice to the Engineer.

END OF SECTION
SECTION 237523 ROOFTOP HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged rooftop heating and cooling units.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer’s technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings:

1. Submit shop drawings detailing the manufacturer’s electrical requirements for power supply wiring for rooftop heating and cooling units. Submit manufacturer’s ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

2. Submit shop drawings detailing the mounting, securing, and flashing of the roof curb to the roof structure. Indicate coordinating requirements with roof membrane system.

C. Operation and Maintenance Data: Submit maintenance data and parts list for each rooftop unit, including “trouble-shooting” maintenance guide, servicing guide and preventative maintenance schedule and procedures.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of rooftop heating and cooling units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Regulatory Requirements:

1. Gas-fired furnace section construction shall be in accordance with AGA safety standards. Furnace section shall bear the AGA label.

2. Testing and rating of rooftop units of 135,000 btu/hr capacity or over shall be in accordance with ARI 360 “Standard for Commercial and Industrial Unitary Air-Conditioning Equipment.”

3. Testing and rating of rooftop units under 135,000 btu/hr capacity shall be in accordance with ARI 210 “Standard for Unitary Air-Conditioning Equipment”, and provide Certified Rating Seal. Sound testing and rating of units shall be in accordance with ARI 270 “Standard for Sound Rating of Outdoor Unitary Equipment.” Units shall bear Certified Rating Seal.

4. Refrigerating system construction of rooftop units shall be in accordance with ASHRAE 15 “Safety Code for Mechanical Refrigeration.”
5. Energy Efficiency Ratio (EER) of rooftop units shall be equal to or greater than prescribed by ASHRAE 90.1 “Energy Standard for Buildings except Low-Rise Residential Buildings.”

6. Rooftop units shall be listed by UL and have UL label as a unit.

1.4 SCHEDULING AND SEQUENCING

A. Coordinate installation of roof mounting curb as follows:
   1. Furnish manufacturer’s standard roof curb for each piece of equipment.
   2. Curb shall be installed and flashed by the Division 07 Contractor.
   3. Installation of roof mounted equipment on the curb shall be by the Division 23 Contractor.
   4. All flashing and roofing shall be by the Division 07 Contractor.

B. Coordinate roof opening with the Division 07 Contractor.

1.5 SPECIAL WARRANTY

A. Warranty on Compressor and Heat Exchanger: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors and heat exchangers with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer’s instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.
   1. Warranty Period: 5 years from date of substantial completion.

B. Warranty to commence after commissioning and complete system acceptance

1.6 MAINTENANCE

A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each rooftop heating and cooling unit:
   1. One set of matched fan belts for each belt-driven fan.
   2. One set filters for each unit.

PART 2 - PRODUCTS

2.1 ROOFTOP UNITS LESS THAN 20 TONS

A. Manufacturers: Subject to compliance with requirements, provide rooftop units of one of the following:
   1. Carrier Air Conditioning; Div of Carrier Corp.
   2. Trane (The) Co; Div of American Standard Inc.
   4. Daikin McQuay.

B. General Description: Units shall be factory-assembled and tested, designed for roof or slab installation, and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics are scheduled on the Drawings.
C. Casing: manufacturer’s standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1” thick thermal insulation, knockouts for electrical and piping connections and an exterior condensate drain connection and lifting lugs.

D. Roof Curbs: manufacturer’s standard construction, insulated and having corrosive protective coating, complete with factory- installed wood nailer and drain nipple. Construction shall be in accordance with NRCA Standards.

E. Evaporator fans: forward-curved, centrifugal, belt-driven fans with adjustable sheaves or direct-driven fans; and permanently lubricated motor bearings.

F. Condenser fans: propeller-type, direct-driven fans with permanently lubricated bearings.

G. Coils:
   1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.
   2. Refrigerant cooling coils: have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be proof (450 psig) and leak (300 psig) tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.

H. Compressors: Serviceable, fully hermetic compressors, complete with integral vibration isolators and crankcase heaters.

I. Safety controls: Manual reset type for:
   1. Low pressure cutout;
   2. High pressure cutout;
   3. Compressor motor overload protection.

J. Heat exchangers: manufacturer’s standard construction for gas- fired heat exchangers and burners.
   1. Controls:
      a. Redundant gas valve;
      b. Electronic spark ignition system;
      c. High limit cutout;
      d. Forced draft proving switch.

K. Economizer control: return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control, and adjustable mixed-air thermostat. System shall have 100 percent outside air capability. Provide automatic changeover through adjustable enthalpy control device.

L. Variable air volume control: discharge air step controller, and electric control system with enthalpy control.
M. Electric heat sections: auxiliary electric heat coils, of manufacturer’s standard construction, factory-wired for single point wiring connection, complete with over-current and over-heat protection devices.

N. Accessories: Units shall include the following accessories as indicated or scheduled:

1. Low ambient control: head pressure control, designed to operate at temperatures down to 0°F (-18°C).

2. Thermostat: Assembly shall provide for staged heating and cooling with manual or automatic changeover on standard subbase.

2.2 ROOFTOP UNITS 20 TONS AND LARGER

A. Manufacturers: Subject to compliance with requirements, provide rooftop units of one of the following:

1. Carrier Air Conditioning; Div of Carrier Corp.
2. Trane (The) Co; Div of American Standard Inc.

B. General Description: Rooftop unit shall be factory-assembled and tested, designed for roof or slab installation and, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics are scheduled on the Drawings.

C. Casing manufacturer’s standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 2” thick thermal insulation, knockouts for electrical and piping connections, and an exterior condensate drain connection, and lifting lugs.

D. Roof curbs: manufacturer’s standard construction, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple. Construction shall be in accordance with NRCA Standards.

E. Evaporator fans: forward-curved, centrifugal, airfoil, belt-driven fans with adjustable sheaves; and permanently lubricated motor bearings.

F. Condenser fans: propeller-type, direct-driven fans with permanently lubricated bearings.

G. Coils:

1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.

2. Refrigerant cooling coils: have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be proof (450 psig) and leak (300 psig) tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.
H. Compressors: serviceable, semi-hermetic, or hermetic compressors with integral vibration isolators, and crankcase heaters which de-energize during compressor operation. Units shall also have:

1. Cylinder unloaders for capacity control, with minimum steps as scheduled;

2. APR Control Device for variable volume systems: Provide integral hot gas capacity control and humidity control device. Provide device factory mounted, installed, piped and connected; match control device capacity to heat pump capacity. Provide all necessary components, piping, accessories and appurtenances including de-superheater and liquid injection valve. Hot gas capacity control device shall be integrally controlled as part of packaged heat pump.

3. Thermal expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves; minimum of 2 refrigerant circuits for units having 2 or more compressors; and fan-cycling control for low ambient control to 35°F (2°C).

I. Safety Controls:

1. Low pressure cutout, manual reset;

2. High pressure cutout, manual reset;

3. Compressor motor overload protection, manual reset;

4. Anti-recycling timing device;

5. Adjustable low-ambient lockout;

6. Oil pressure switch.


1. Controls:
   
   a. Redundant gas valves;
   b. Electronic spark ignition system;
   c. High limit cutout;
   d. Forced draft proving switch;
   e. Flame roll-out switch.

K. Economizer control: return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control, and adjustable mixed-air thermostat. System shall have 100 percent outside air capability. Provide automatic changeover through adjustable enthalpy control device.

L. Variable air volume control: discharge air step controller, electric control system with enthalpy control, and 7-day programmable time clock.

M. Electric heat sections: manufacturer’s standard construction auxiliary electric heat coils, factory-wire for single point wiring connection. Complete with over-current and over-heat protection devices.

N. Filters section: 2” thick fiberglass throwaway filters in filter rack, with maximum face velocity of 300 fpm.

O. Electrical: Units shall have a 115 VAC convenience outlet, separately fused, for unit service. Unit power connection shall be either through unit cabinet or within roof curb perimeter.
P. Temperature control: factory-installed, demand-oriented solid-state control system with minimum of 2 cooling steps and 2 heating steps. Controls shall include solid-state thermostats with dead-band, and sub-base with system and fan switches. Other control features include:

1. Discharge temperature reset capability with space temperature override;
2. 7-day programmable time clock, with power failure carryover, for remote mounting;
3. Warm-up cycle.

Q. Accessories: Units shall include the following accessories as indicated or scheduled:

1. Remote Control Panel: Furnish panel for remote mounting containing control of heating, cooling, evaporator fan, and outdoor damper; and indicator lights for up to 6 unit functions.
2. Anti-recycling control to automatically prevent compressor restart for 5-minutes after shutdown.
3. Low ambient control head pressure control, designed to operate at temperatures down to 0°F (-18°C).
4. Thermostat: Assembly shall provide for staged heating and cooling with manual or automatic changeover on standard subbase.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which rooftop units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

A. General: Install rooftop units in accordance with manufacturer’s installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer’s recommended clearances.

B. Support: Installation of roof curbs shall be by the Division 07 Contractor.

C. Electrical Connections: Refer to Division 26 for final electrical connections to equipment and installation of loose shipped electrical components.

3.3 DEMONSTRATION

A. Start-Up Services:

1. Provide the services of a factory-authorized service representative to start-up rooftop units, in accordance with manufacturer’s written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
B. Operating and Maintenance Training:

1. Provide services of manufacturer’s service representative to instruct Owner’s personnel in operation and maintenance of rooftop units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and troubleshooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals.
   a. Schedule training with Owner, provide at least 7-day prior notice to the Engineer.

END OF SECTION
SECTION 238126 DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for recessed ceiling or surface wall mounting.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Diagram power, signal, and control wiring, dimensional drawings, weights, and accessories.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."


1.4 COORDINATION

A. Coordinate size, location, and connection details with roof supports, equipment supports, and roof penetrations.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Warranty to commence after commissioning and complete system acceptance.
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. Carrier Air Conditioning; Div. of Carrier Corporation.
2. Comfort Air.
3. Mitsubishi Electronics America, Inc.; HVAC Division.
5. Daikin McQuay.
6. Trane.

2.2 CEILING RECESSED EVAPORATOR-FAN COMPONENTS

A. Chassis: High-strength molded plastic, removable panels for servicing.

1. Drain Pans: Polycarbonate plastic, with connection for drain; insulated.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Fan: Direct drive centrifugal; double inlet, forward curve.

1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

D. Permanent, Cleanable Filters: 1/2 inch (25 mm) thick plastic screen.

E. Wiring Terminations: Connect motor to chassis wiring with plug connection.

F. Condensate Pump: Integral with unit.

2.3 WALL SURFACE EVAPORATOR-FAN COMPONENTS

A. Chassis: High-strength molded plastic, removable panels for servicing.

1. Drain Pans: Polycarbonate plastic, with connection for drain; insulated.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Fan: Direct drive centrifugal; double inlet, forward curve.

1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
D. Permanent, Cleanable Filters: 1/2 inch (25 mm) thick plastic screen.

E. Wiring Terminations: Connect motor to chassis wiring with plug connection.

F. Condensate Pump: Integral with unit.

2.4 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Galvanized steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

1. Compressor Type: Scroll.

2. Inverter controlled compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

3. Refrigerant: R-410A.

4. APR Control Device: Provide integral hot gas capacity control and humidity control device. Provide device factory mounted, installed, piped and connected; match control device capacity to heat pump capacity. Provide all necessary components, piping, accessories and appurtenances including de-superheater and liquid injection valve.

5. Hot gas capacity control device shall be integrally controlled as part of packaged heat pump.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Fan: Polycarbonate plastic-propeller type, directly connected to motor.

E. Motor: Permanently lubricated, with integral thermal-overload protection.

2.5 ACCESSORIES

A. Low ambient operation control kit: Permits operation down to 0°F.

B. Roof equipment rails (for condensing unit) galvanized steel, 12” tall with built in cant strip and encased wooden mounting strip.

C. Sensor: Hard wired, 12 volt DC functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.

2. 24-hour time control of system stop and start.

3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.

4. Fan-speed selection, including auto setting.
D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction and liquid line with flared fittings at both ends.
   1. Minimum Insulation Thickness: 1/2 inch (13 mm).

F. Fresh Air Intake Kits: Accessory collars and baffles to permit introduction of fresh air into unit housing.

G. Control adapter to allow unit to enable/disable through the Building Automation System.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

D. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

E. Connect condensate drain tubing from integral condensate pump discharge to termination point indicated.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.
3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   
1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

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

END OF SECTION
SECTION 238200 TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Extent of terminal unit work is indicated by drawings and schedules, and by requirements of this section.

B. Types of terminal units required for project include the following:
   1. Finned tube radiation.
   2. Unit heaters.
   3. Unit ventilators.

C. Refer to other Sections for piping; ductwork; and testing, adjusting and balancing of terminal units; not work of this section.

D. Refer to other Sections for the following work; not work of this section.
   1. Power supply wiring from power source to power connection on terminal unit. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
   2. Interlock wiring between electrically-operated terminal units; and between terminal units and field-installed control devices.
      a. Interlock wiring specified as factory-installed is work of this section.

E. Provide the following electrical work as work of this section. Complying with requirements of other Sections:
   1. Control wiring, specified in other Sections, between field-installed controls, indicating devices, and terminal unit control panels.

1.2 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:
   1. I-B-R Compliance: Test and rate baseboard and finned tube radiation in accordance with I-B-R, provide published ratings bearing emblem of I-B-R.
   3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 “Methods of Testing Forced Circulation Air Cooling and Heating Coils.”
   4. ARI Compliance: Test and rate unit ventilators in accordance with ARI Standard 330 “Unit Ventilators.”
5. UL Compliance: Provide electrical components for terminal units which have been listed and labeled by UL.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s specifications for terminal units showing dimensions, capacities, ratings, performance characteristics, gages and finishes of materials, and installation instruction.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.

C. Wiring Diagrams: Submit manufacturer’s electrical requirements for power supply wiring to terminal units. Submit manufacturer’s ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Samples: Submit 3 samples of each type of cabinet finish furnished.

E. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.

B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer’s rigging and installation instructions for unloading terminal units, and moving them to final location.

PART 2 - PRODUCTS

2.1 FINNED TUBE RADIATION

A. General: Provide finned tube radiation of lengths and in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum 18-ga cold-rolled steel full backplate, minimum 16-ga front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.

C. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.

D. Finish: Flat black heat resisting paint for backplate; factory-finished baked enamel, standard colors, on fronts and accessories.

E. Accessories:

1. End panels, inside and outside corners, and enclosure extensions.
2. Access panels in front of valves, balancing cocks, and traps.
3. Factory-mounted dampers.
4. Sill extensions.
5. Mullion channels.
6. Pilaster covers.

F. Available Manufacturers: Subject to compliance with requirements, manufacturers offering finned tube radiation which may be incorporated in the work included, but are not limited to, the following:

1. Dunham-Bush, Inc.
2. Edwards Engineering Corp.
3. Slant/Fin Corp.
4. Standard Fin-Pipe Radiator Corp.
5. Sterling Radiator; Div. of Reed National Corp.
6. Trane (The) Co.
7. Vulcan Radiator Co.

2.2 UNIT HEATERS

A. General: Provide unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Horizontal Unit Heaters:

1. Casings: Construct of steel, phosphatized inside and out, and finished with baked enamel. Design casing to enclose fan, motor, and coil, design fan orifice formed into discharge panel. Provide air diffusers as scheduled.

2. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.

C. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in hot water applications.

D. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering unit heaters which may be incorporated in the work include, but are not limited to, the following:

2. Buffalo Forge Co.
3. Dunham-Bush, Inc.
4. McQuay Inc.
6. Trane (The) Co.
8. Young Radiator Co.

2.3 COILS

A. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410.
B. Heating Coils:

1. Fins: Construct of continuous aluminum or copper configurated plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.

2. Tubes: Construct of copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leaktight joint.

3. Headers: Construct of gray cast iron for coils 33” high and smaller. Hydrostatically test to 400 psi before assembly. Construct of round seamless copper tube for coils over 33” high.

4. Casings: Construct of 16-ga continuous coated galvanized steel with fins recessed into channels to minimize air bypass.

5. Testing: Proof test coils at 300 psi, leak test at 200 psi under water.

6. Coil Types: Provide the following coil types as indicated, and as scheduled:
   a. Hot Water to 200 psi, 250degGF (121degC): Provide 1-row, 5/8” tubes, opposite-end connection coil.
   c. Hot Water to 200 psi, 220degF (104degC): Provide 2-row, 5/8” tubes, same-end connection coil. Provide rolled tube-to-header joints for coil heights 33” and smaller. Provide brazed tube-to-header joints for coil heights over 33”.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering coils which may be incorporated in the work include, but are not limited to, the following:

1. Aerofin Corp.
2. American Air Filter; Allis-Chalmers Co.
3. Carrier Cor.
4. Dunham-Bush, Inc.
5. McQuay Inc.
6. Trane (The) Co.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF FINNED TUBE RADIATION

A. General: Install finned tube radiation as indicated, and in accordance with manufacturer’s installation instructions.

B. Locate finned tube radiation on outside walls as indicated, run cover wall-to-wall unless otherwise indicated.
C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.

3.3 INSTALLATION OF UNIT HEATERS

A. General: Install unit heaters as indicated, and in accordance with manufacturer’s installation instructions.

B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.

C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.

D. Support units with rod-type hangers anchored to building substrate.

E. Install piping as indicated.

F. Protect units with protective covers during balance of construction.

3.4 INSTALLATION OF COILS

A. General: Install coils as indicated, and in accordance with manufacturer’s installation instructions.

B. Mount coils on steel supports to form banks or stacks as indicated, brace, secure to air intake chamber. Place in location to permit installation of bypass damper if required, provide steel baffles where required to prevent bypassing of air.

C. Pitch coil casings for drainage, not less than 1/8” toward return connections, except where drainage feature is included in coil design.

D. Provide for each bank of cooling coils, stainless steel drain pan under each coil supported off of floor of sufficient height to allow installation of condensate trap to allow drainage of condensate from pan when installed on suction side of fan.

E. Provide for each hot or chilled water coil unit, water supply, return connection, strainer, gate valves, automatic temperature regulating valve, balancing cocks, as indicated.

3.5 ELECTRICAL WIRING

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer’s submittal and installation requirements of other Sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.6 ADJUSTING AND CLEANING

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Install new filter units for terminals requiring same.

END OF SECTION
PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Provide all labor, material, tools, equipment, transportation, and services necessary for and incidental to completion of all electrical work as indicated on the Drawings and/or as specified herein.

1.2 DRAWING USE AND INTERPRETATION

A. The Drawings are diagrammatic and indicate the general arrangement of systems and equipment unless indicated otherwise by dimensions or details. Exact equipment locations and raceway routing, etc. shall be governed by actual field conditions and/or instructions of the Engineer and/or Owner’s Representative.

1.3 COMPLETE SYSTEMS

A. General: Furnish and install all materials as required for complete systems, including all parts obviously or reasonably incidental to a complete installation, whether specifically indicated or not. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation prior to Owner’s acceptance.

B. Wiring: The wiring specified and/or shown on the Drawings is for complete and workable systems. Any deviations from the wiring shown due to a particular manufacturer’s or subcontractor’s requirements shall be made at no cost to either the Contract or the Owner.

1.4 CODES AND REGULATIONS

A. General: Comply with the latest recognized edition of the National Electrical Code (NEC) and all governing federal, state, and local laws, ordinances, codes, rules, and regulations. Where the Contract Documents exceed these requirements, the Contract Documents shall govern. In no case shall work be installed contrary to or below minimum legal standards.

B. Utilities: Comply with all applicable rules, restrictions, and requirements of the utility companies serving the project site/facilities.

C. Non-Compliance: Should any work be performed which is found not to comply with any of the above codes and regulations, provide all work and pay all costs necessary to correct the deficiencies.

1.5 REFERENCE STANDARDS

A. All latest published standards of the following associations/organizations shall be followed and applied where applicable as minimum requirements:

1. (ADA), Americans with Disabilities Act.
2. (ANSI), American National Standards Institute.
4. (CBM), Certified Ballast Manufacturer.
6. (ETL), Electrical Testing Laboratory.
7. (ICEA), Insulated Cable Engineers Association.
8. (IEEE), Institute of Electrical and Electronic Engineers.
10. (NBFU), National Board of Fire Underwriters.
11. (NEMA), National Electrical Manufacturers Association.
14. (UL), Underwriter’s Laboratories.

1.6 PERMITS

A. General: Obtain and pay for any and all permits required by all applicable agencies, prior to commencing work.

1.7 SUBMITTALS

A. General: Prepare and submit for approval, per the procedures set forth in Division 1, all submittals required by Division 1, this section, and by all other Contract Documents.

B. Types: Required submittals may include: Schedule of Values; List of Subcontractors; Product Data; Shop Drawings; Samples; Test Reports; Certifications; Warranties; Maintenance Manuals; Record Drawings; and various administrative submittals.

C. Number of Copies: As indicated in Division 1, Division 26, or elsewhere in the Contract Documents. For quantities indicated in the Contract Documents or specification sections other than Division 26 sections, increase number of copies by one to allow for the Engineer’s record copy. Minimum number of copies per submittal: three.

D. Product Data: Submit for all basic electrical equipment, devices, and materials to be used on the project. Product data to consist of manufacturer’s standard catalog cuts, descriptive literature and/or diagrams, in 8-1/2-inch-by-11-inch format, and in sufficient detail so as to clearly indicate compliance with all specified requirements and standards. Mark each copy to clearly indicate proposed product, options, finishes, etc.

E. Shop Drawings: Submit for all custom equipment and systems (e.g., panelboards) to be used on the project. Shop Drawings to be newly prepared, specifically for this project, and shall include all information listed in the Shop Drawings submittal requirements in the respective specification section. Include all pertinent information such as equipment/system identification, manufacturer, dimensions, nameplate data, sizes, capacities, types, materials, performance data, features, accessories, wiring diagrams, etc., in sufficient detail so as to clearly indicate compliance with all specified requirements and standards. For control systems, provide computer generated control ladder diagrams specifically developed for this project (standard diagrams not acceptable).

F. Maintenance Manuals: Include operating and maintenance data in accordance with Division 1. Include all Product Data/Shop Drawing submittals as well as descriptions of function, normal operating characteristics and limitations, and manufacturer’s printed operating maintenance, trouble shooting, repair, adjustment, and emergency instructions, and complete replacement parts listing.

G. Record Documents: Prepare and submit in accordance with Division 1. In addition to Division 1 requirements, indicate actual installed locations for all equipment and devices, routing of major interior raceways, locations of all concealed and underground equipment and raceways, and all approved modifications to the Contract Documents, and deviations necessitated by field conditions and change orders.
1.8 QUALITY ASSURANCE

A. Manufacturers’ Qualifications: Not less than three (3) years experience in the actual production of the specified products.

B. Installers’ Qualifications: Firm with not less than five (5) years experience in the installation of electrical systems and equipment similar in scope and complexity to those required for this Project, and having successfully completed at least ten comparable scale projects.

C. Incidental Work: Excavation, backfill, painting, patching, welding, carpentry, mechanical work, concrete pads and the like related to or required for Division 26 work shall be performed by craftsman skilled in the appropriate trade, but shall be provided for under Division 26.

1.9 INSPECTIONS

A. General: During and upon completion of the work, arrange and pay all associated costs for inspections of all electrical work installed under this contract, in accordance with the Conditions of the Contract.

B. Inspections Required: As per the laws and regulations of the local and/or state agencies having jurisdiction at the project site.

C. Inspection Agency: Approved by the local and/or state agencies having jurisdiction at the project site.

D. Certificates: Submit all required inspection certificates.

E. Coordination: Coordinate inspections with the local utility.

1.10 DELIVERY STORAGE AND HANDLING

A. Comply with Division 1 requirements.

B. Packing and Shipping: Deliver products in original, unopened packaging, properly identified with manufacturer’s identification, and compliance labels.

C. Storage and Protection: Comply with all manufacturer’s written recommendations. Store all products in a manner, which shall protect them from damage, weather, and entry of debris.

D. Damaged Products: Do not install damaged products. Arrange for prompt replacement.

PART 2 – PRODUCTS

2.1 GENERAL

A. Where Specified: Materials and equipment shall be as specified herein and/or as indicated on the Drawings.

B. General Requirements: All materials and equipment shall be in accordance with the Contract Documents, and to the extent possible, standard products of the various manufacturers, except where special construction or performance features are called for. All materials and equipment to be new, clean, undamaged, and free of defects and corrosion.
C. Acceptable Products: The product of a specified or approved manufacturer will be acceptable only when that product complies with or is modified as necessary to comply with all requirements of the Contract Documents.

D. Common Items: Where more than one of any specific item is required, all shall be of the same type and manufacturer.

E. UL Listing: All electrical materials and equipment shall be Underwriters’ Laboratories (UL) listed and labeled where UL standards and listings exist for such materials or equipment.

2.2 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Refer to the Conditions of the Contract and Division 1.

2.3 FIRESTOPPING MATERIALS

A. General: Firestop systems composed of firestop compounds and appropriate damming materials installed together with the penetrant (e.g., conduit) to form a complete firestop system, providing a fire resistant rating at least equal to the hourly fire resistance rating of the floor, wall or partition into which the firestop system is to be installed.

B. Test Standards: Firestopping materials shall be tested together as a system to the time/temperature requirements of ASTM E119 and shall be tested to UL 1479 (ASTM E814) and be UL classified for up to 3 hours.

C. Firestop Sealants: Non-hardening, conformable, intumescent putties, sealants or other compounds, containing no toxic solvents or asbestos, and exhibiting aggressive adhesion to all common building materials and penetrants, while allowing reasonable movement of the penetrants, without being displaced. Compounds shall be waterproof, non-toxic and smoke and gas tight.

D. Firestop Mortars: Light-weight, water-based, cementitious, fast drying, low density mortar, non-shrinking and non-cracking during its cure, and which forms a surface capable of being sanded, bored and painted.

E. Damming Materials: Mineral wool or ceramic fiber.

F. Multi-Cable Transits: Assemblies consisting of a frame, a compression mechanism, and grooved insert sealing modules sized for multiple penetrating elements of various sizes.


2.4 RACEWAY SYSTEMS

A. Raceway Sizing: As required by the NEC (minimum) with oversized raceways as indicated and where required for ease of pulling cable. Minimum conduit size: 3/4 inch, unless indicated otherwise.

B. Raceway Types: Rigid galvanized steel conduit, electrical metallic tubing (EMT), flexible steel conduit, liquid-tight flexible steel conduit and Schedule 40 heavywall and Schedule 80 extra-heavywall rigid non-metallic (PVC) conduit conforming to applicable ANSI, NEMA and UL standards.

C. Fittings: All raceway fittings (except for rigid non-metallic conduit) to be steel or malleable iron and UL-listed for the intended application. EMT fittings to be compression type.
D. Outlet Boxes (Concealed in Walls): Non-gangable, galvanized steel with square cornered tile (or masonry) type extension rings or cover. Minimum size: two-gang masonry box or 4-inch square box with single-gang adapter (plaster) ring. Depth of adapter ring to suit application. Minimum depth: 1-1/2 inches. Minimum capacity: 21 cubic inches.

E. Outlet Boxes (Surface Mounted): Cadmium plated cast or malleable iron.

F. Pull and Junction Boxes, and Wireways: Use as indicated and required. Junction and pull boxes for general indoor use (dry locations) to be of galvanized code gauge steel construction, minimum 4-inch square by 1-1/2 inches deep with screw-on covers. Wireways to be UL listed, sheet steel construction with screw-on covers. For exterior and damp or wet indoor locations, use boxes and wireways approved for such use.

G. Pipe Sleeves: Rigid steel conduit or iron pipe.

H. Conduit Seals: For Cast-in-Place Concrete Applications:
   1. Acceptable Manufacturers:
      a. O-Z/Gedney Type “FSK.”
      b. Thunderline Corp. “Link Seal” with “Link Seal Wall Sleeve.”

I. For Core Drilled and Pre-Cast Opening Applications:
   1. Acceptable Manufacturers:
      a. O-Z/Gedney Type “CSML.”
      b. Thunderline Corp. “Link Seal.”

J. Pull Wires: No. 14 AWG zinc-coated steel monofilament plastic line with 200-pound tensile strength.

2.5 600 VOLT CLASS WIRE

A. General: All wire and cable shall be constructed in accordance with all applicable ICEA, NEMA and IEEE published standards, and shall be UL-listed and labeled. Single-conductor, 98 percent conductivity, annealed, uncoated copper conductors with 600-volt rated type “THHN/THWN” insulation.

B. Wire shall be annealed bare copper per ANSI/ASTM B3, UL 83, and Federal Specification JC-30A with 600 volt insulation, be stranded (except for #10 AWG and smaller may be solid), and be minimum size #12 AWG (except for control wiring and signal circuits).

C. Insulation: Provide THHN/THWN insulation for all conductors except XHHW insulation may be used for conductors #4 and larger.

D. Fire Pump Wiring: Provide UL 2196 classified 2-hour fire rating cable. Cable shall be UL-listed type RHH/RHW-2 similar to Drake USA Lifeline RHW-2.

E. Ampacity of conductors shall be rated for 75 DegC regardless of temperature of conductor insulation when combining circuits in one conduit. Derate conductors and increase size per NEC when installing multiple circuits in a raceway, utilizing 75 DegC ampacity table.

F. Connectors: Nylon shell insulated metallic screw-on connectors for #14-10 AWG and bolted pressure or compression type lugs and connectors with insulating covers for #8 AWG and larger.
2.6 WIRING DEVICES

A. Switches: 20 amp, 120-277 volt, A.C. only, toggle type, single-pole, double-pole, three-way or four-way as indicated or required.
   1. Acceptable Manufacturers:
      a. Leviton.
      b. Arrow-Hart.
      c. Hubbell.
      d. Pass and Seymour.

B. Receptacles (General Use): 125 volt, 20 amp, NEMA 5-20R, duplex type.
   1. Acceptable Manufacturers:
      a. Leviton.
      b. Arrow-Hart.
      c. Hubbell.
      d. Pass and Seymour.

C. GFI Receptacles: Ground fault circuit interrupter, feed-through, duplex type, 125 volt, 20 amp, NEMA 5-20R, with solid-state ground-fault sensing and 5 mA trip level.
   1. Acceptable Manufacturers:
      a. Leviton.
      b. Arrow-Hart.
      c. Hubbell.
      d. Pass and Seymour.

D. Special Receptacles: As indicated by ratings and/or NEMA configuration.
   1. Acceptable Manufacturers:
      a. Leviton.
      b. Arrow-Hart.
      c. Hubbell.
      d. Pass and Seymour.

E. Combination USB, Simplex Receptacle: Tamper resistant simplex NEMA 5-15R decorator receptacle and two (2) standard type “A” USB receptacles rated 2.1 amps, 2100ma, 10 5W.
   1. Acceptable Manufacturers:
      a. Legrand.

F. Device Color: Brown, unless directed otherwise.

G. Coverplates (Interior Devices): For finished spaces, nylon coverplates to match wiring device. For unfinished spaces (e.g., mechanical room, electrical room, etc.), minimum .032 inch thick, Type 430 stainless steel with U.S. #32D satin finish.

H. Coverplates (Exterior Locations): Weatherproof cast aluminum or polycarbonate. Receptacles installed in damp or wet locations shall have an enclosure and cover that are weatherproof with the attachment plug inserted or removed per NEC 406.9.
2.7 EQUIPMENT CONNECTIONS

A. Materials as specified in this section, and as required.

2.8 HANGERS AND SUPPORTS

A. General: All hangers, supports, fasteners and hardware shall be zinc-coated or of equivalent corrosion resistance by treatment or inherent property, and shall be manufactured products designed for the application. Products for outdoor use shall be hot dip galvanized.

B. Types: Hangers, straps, riser supports, clamps, U-channel, threaded rods, etc., as indicated and/or required.

2.9 ELECTRICAL IDENTIFICATION

A. Nameplates: Three-layer laminated plastic with minimum 3/16 inch high white engraved characters on black background, and punched for mechanical fastening. Fasteners: self-tapping stainless-steel screws or number 10-32 stainless steel machine screws with nuts and flat and lock washers. Each nameplate on all panelboards and switchgear shall indicate the following:
   1. Panel Name.
   2. Voltage, Phase, Number of Wires.
   3. Source.

B. Underground Warning Tape: 6-inch wide polyethylene tape, permanently bright colored with continuous-printed legend indicating general type of underground line below and “CAUTION.” Colors as follows:
   2. Orange – Communications.

C. Marking Pens: Permanent, waterproof, quick drying black ink.
   1. Acceptable Manufacturers:
      a. Sanford Fine Point “Sharpie.”
      b. Or equal.

D. Wire Tags: Vinyl or vinyl-cloth self-adhesive wraparound type indicating appropriate circuit number, etc.

E. Arc Flash Panelboard Stickers: Provide per NEC 110.16.

2.10 SAFETY SWITCHES

A. General: Heavy duty, horsepower rated, fully enclosed, fusible (with rejection fuse clips) or non-fused as indicated, quick-make, quick-break switching mechanism interlocked with cover and NEMA-1 enclosure for dry locations and NEMA-3R enclosure for wet locations unless indicated otherwise. Switches to be labeled as “Suitable for Use as Service Entrance Equipment” where so indicated or required.

B. Ratings: Provide switches with ratings as indicated. If ratings are not indicated, provide switch with ratings to suit the electrical system and load served.
C. Acceptable Manufacturers:
   1. General Electric.
   2. Square D.
   4. Siemens.

2.11 GROUNDING

A. General: Conductors, clamps and connectors, etc., as required.

B. Welded Connectors: Exothermic process.

2.12 DRY TYPE TRANSFORMERS

A. General: Transformers shall be UL listed and labeled and meet all applicable NEMA, ANSI, and IEEE standards. Transformers shall be factory assembled, general purpose, ventilated type of size, and electrical characteristics indicated.

B. Enclosure: Ventilated, drip-proof code gauge steel housing with bolted removable access panels, phosphatized and finished with corrosion inhibiting undercoat and ANSI-61 gray baked enamel. Transformers shall be suitable for mounting on floor or other substantial structure except for 15 KVA size and smaller which shall be suitable for wall mounting.

C. Core and Coil: Constructed of continuous copper windings and high-grade non-aging, grain-oriented silicon steel core laminations having high magnetic permeabilities and low hysteresis and eddy current losses. Core and coil of units rated 15 KVA or more shall be completely isolated from the enclosure using vibration absorbing mounts and shall have flexible grounding strap connected to the enclosure. Connections to primary and secondary bushing shall be made using fully rated flexible straps.

D. Insulation System: 220 DegC temperature class for all transformers.

E. Temperature Rise: Winding temperature rise by resistance limited to 115 DegC for all transformer sizes referenced to 40 DegC ambient temperature. Hot spot temperature shall not exceed 30 DegC above winding temperature rise rating. Case temperature shall not exceed 35 DegC above 40 DegC ambient temperature.

F. Taps: Two 5 percent FCBN taps for transformer sizes below 30 KVA; and two 2-1/2 percent FCAN and four 2-1/2 percent FCBN taps for transformer sizes 30 KVA and larger; referenced to nameplate voltage.

G. Noise Levels: Less than ANSI standards and shall meet the following requirements:
   1. 15 to 50 kVA: 45 dB.
   2. 51 to 150 kVA: 50 dB.
   3. 151 to 300 kVA: 55 dB.
   4. 301 to 500 kVA: 60 dB.
   5. 501 to 700 kVA: 62 dB.
   6. 701 to 1000 kVA: 64 dB.
H. Efficiencies shall be as indicated in the following table:

| NEMA CLASS I EFFICIENCY LEVELS FOR DRY-TYPE TRANSFORMERS |  
|---------------------------------------------------------|--------------------------------------------------|
| SINGLE-PHASE EFFICIENCY                                | THREE-PHASE EFFICIENCY                           |
| 15 kVA                                                 | 97.7                                             |
| 15 kVA                                                 | 97.0                                             |
| 25 kVA                                                 | 98.0                                             |
| 30 kVA                                                 | 97.5                                             |
| 37.5 kVA                                               | 98.2                                             |
| 45 kVA                                                 | 97.7                                             |
| 50 kVA                                                 | 98.3                                             |
| 75 kVA                                                 | 98.0                                             |
| 75 kVA                                                 | 98.2                                             |
| 100 kVA                                                | 98.5                                             |
| 112.5 kVA                                              | 98.2                                             |
| 167 kVA                                                | 98.6                                             |
| 225 kVA                                                | 98.5                                             |
| 250 kVA                                                | 98.8                                             |
| 300 kVA                                                | 98.6                                             |
| 333 kVA                                                | 98.9                                             |
| 500 kVA                                                | 98.7                                             |
| 750 kVA                                                | 98.8                                             |
| 1000 kVA                                               | 98.9                                             |

I. Ratings: KVA rating, voltages, phases, and configuration as indicated. Minimum impedance: 4.5 percent.

J. Nameplates: The nameplate shall be permanently mounted to the exterior front with permanently etched numbers and letters and shall include the following:
1. KVA size.
2. Primary and Secondary Voltage Ratings.
3. Serial Number.
4. Weight.
5. Composition of Windings (Primary, Secondary).
7. Percent impedance.
8. Taps.
9. Basic Impulse Level.

K. Acceptable Manufacturers:
1. General Electric.
2. Square D.
4. Siemens.
5. ACME.

2.13 PANELBOARDS

A. Types: Two-row, bolt-on circuit breaker branch circuit panelboards, and circuit breaker or fusible switch-type distribution panelboards, as indicated or required.

B. General: Ratings, mains, mounting and complement of branch overcurrent protective devices as indicated below or on the Drawings.
C. Short Circuit Ratings: Minimum 10,000 amps for 208/120 volt panelboards and 14,000 amps for 480/277 volt panelboards. Provide panelboards with higher ratings as indicated or as required.

D. Enclosures: NEMA-1 for dry locations and NEMA 3R for wet locations (unless indicated otherwise). Provide galvanized steel rough-in box and cover with gray enamel finish Panel fronts are to have a door (circuit breakers) in door (circuit breakers & wiring gutters) in trim with concealed hinges and flush type tumbler lock. All panels shall be keyed alike. Doors in excess of 48 inches high shall be equipped with a three-point catch and vault handle with integral tumbler lock. Panel shall be dead front, safety type and be multi-section as noted or as necessary to comply with NEC.

E. Bussing: Full capacity copper, include solid copper ground bus, bonded to enclosure and solid copper neutral bus with lug for each branch circuit

F. Fusible Switches: Quick-make, quick-break, horsepower rated with rejection fuse clips, padlockable handle, and hinged door with defeatable interlock.

G. Acceptable Manufacturers:
   1. General Electric “A Series” and “Spectra Series.”
   2. Square D “NQOD,” “NEHB,” “I-Line,” and “QMB.”

H. Panelboard Schedules: Refer to the schedules on the Drawings.

2.14 CIRCUIT BREAKERS

A. General: Molded case with thermal and magnetic trips unless indicated otherwise. Minimum 10,000 amps interrupting capacity for 208V and 240V, 14,000 amps interrupting capacity for 480V and higher ratings as indicated or required.

B. For Panelboard Mounting: Bolt-on type.

C. Individually Mounted: NEMA-1 enclosures for indoor application, NEMA-3R for outdoor application, unless indicated otherwise.

D. Breakers to be added to Existing Panelboards: Same manufacturer, type, and interrupting rating as for the existing breakers in same panelboard.

2.15 FUSES

A. UL Class RK-5 and RK-1, 250 volt or 600 volt as required for system voltage, dual element, time delay, current limiting, 200,000 AIC, ampere ratings as indicated.

B. Acceptable Manufacturers:
   1. Bussmann “Fusetron.”
   2. Or equal by Gould Shawmut.

2.16 INDIVIDUAL MOTOR CONTROLLERS

A. Manual Motor Starters: Fractional horsepower, single-phase, snap action toggle type, which clearly indicates “On,” “Off,” and “Trip” positions with properly sized thermal overload protection, NEMA-1 enclosure (unless indicated otherwise) with handle-locking guard and pilot light.

C. Magnetic Starters: As scheduled or indicated on the Drawings and unless indicated otherwise, NEMA rated (IEC rated not acceptable), full voltage, non-reversing type with properly sized overload protection in all phases, low voltage protection or release and external manual reset. Equip each starter with holding coil rated for 120 volts unless otherwise indicated or required; control circuit transformer sized for the number of devices controlled with dual-fused primary and single-fused secondary (omit for 120 volt starters); and interlock contacts rated for the coil, unit, or motor controlled. If standard interlock contacts are of insufficient quantity and/or ratings, provide auxiliary contacts or relays.

D. Combination Magnetic Starters: Magnetic starters as specified above, with fusible or non-fused switch as indicated, sized as indicated, with defeatable cover interlock, quick-make, quick-break switching mechanism and padlockable indicating handle.

E. Solid-State, Variable Frequency Controllers: Provide controllers listed and labeled as a complete unit and arranged to provide variable speed of a standard NEMA Design B, three-phase, induction motor by adjusting output voltage and frequency of controller. Controller shall be designed and rated by the manufacturer for the type of load (e.g., fans, blowers, pumps, etc.) with which used. Controller shall also be approved by the manufacturer for the type of connection used between the motor and load (direct connection or power transmission connection).

F. Control Devices: Oil-tight type, single hole mounting, mounted in starter covers unless indicated otherwise. Pilot lights to be push-to-test type with transformer and 6 volt lamps with pilot light colors green for motor running and other colors as indicated. Pushbutton stations to include labeled “Start” button, red button labeled “Stop,” and other designations as indicated. Selector switches to be maintained position type, two position “On-Off” and three position “Hand-Off-Auto” when in a circuit with an automatic device and other selector switches as indicated. Minimum Requirements: For each magnetic starter, provide at least a “Run” pilot light and an “Hand-Off-Auto” selector switch unless indicated otherwise. Provide alternate and/or additional control devices as indicated.

G. Enclosures: NEMA-1 for indoor application and NEMA-3R for outdoor application unless indicated otherwise, sized as required to house all components including any optional accessories.

H. Acceptable Manufacturers:
   1. Allen Bradley.
   2. General Electric.
   3. Square D.
   5. Siemens.

PART 3 – EXECUTION

3.1 GENERAL

A. The installation of all electrical work shall be in accordance with the intent of the Contract Documents as determined by the Engineer.
B. Installation Requirements: All materials and equipment shall be installed as recommended by the respective manufacturers, by mechanics experienced and skilled in their particular trade, in a neat and workmanlike manner, in accordance with the standards of the trade, and so as not to void any warranty or UL listing.

C. Administration and Supervision: All electrical work shall be performed under the Contractor’s direct supervision using sufficient and qualified personnel as necessary to complete the work in accordance with the progress schedule. The Contractor shall assign one or more competent supervisors who shall have authority to accept and execute orders and instructions, and who shall cooperate with the other Contractors and subcontractors, the Engineer, and Owner in all matters to resolve conflicts and avoid delays.

3.2 EXAMINATION

A. Conditions Verification: Examine the areas and conditions under which the work is to be performed, and identify any conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.3 COORDINATION

A. General: Sequence, coordinate and integrate the installation of all electrical materials and equipment for efficient flow of work, in conjunction with the other trades. Review to the Drawings for work of the other trades, and report and resolve any discovered discrepancies, prior to commencing work.

B. Cooperation: Cooperate with the other Contractors and individual disciplines for placement, anchorage, and accomplishment of the work. Resolve interferences between work of other disciplines or Contractors, prior to commencing installation.

C. Chases, Slots, and Openings: Arrange for chases, slots, and openings during the progress of construction as required to allow for installation of the electrical work.

D. Supports and Sleeves: 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.

E. Obstacles and Interferences: When installing equipment and raceways, provide offsets, fittings, accessories, and changes in elevation or location as necessary to avoid obstacles and interferences, per actual field conditions.

F. Space Requirements: Electrical equipment sizes indicated on the Drawings are generally based on specified manufacturer. Verify that the proposed equipment will fit in the space indicated on the drawings. Maintain clearances required by NEC.

3.4 DIMENSIONS

A. Building Dimensions: For exact locations of building elements, refer to dimensioned drawings. However, field measurements take precedence over dimensioned drawings.

B. Site Dimensions: Field measurements take precedence over scaled electrical site plans.

C. Limiting Dimensions: Equipment outlines shown on detail drawings of 1/4” = 1’-0” scale or larger and dimensions indicated on the Drawings are limiting dimensions. Do not install equipment exceeding dimensions indicated by outlines on Drawings or equipment or arrangements that reduce indicated clearances.
D. Establish the exact location of electrical equipment based on the actual field verified dimensions of equipment furnished.

3.5 EQUIPMENT PROTECTION

A. Protect all electrical equipment, and materials and work from the weather elements, paint, mortar, construction debris and damage until project is substantially complete. Repair, replace, and clean all electrical work so affected.

3.6 ELECTRICAL INSTALLATION - GENERAL

A. Unfinished and Finished Areas: For the purposes of these electrical specifications, “unfinished” areas shall include mechanical, electrical and telephone equipment rooms. All other areas shall be considered “finished” spaces unless indicated or approved otherwise.

B. In Unfinished Areas: Raceways, equipment, and devices may be installed concealed or exposed unless indicated otherwise.

C. In Finished Areas: Conceal all raceway and flush mount all electrical boxes, equipment, and devices unless indicated or approved otherwise. The space above suspended ceilings or behind furred spaces is considered outside finished areas and electrical materials installed within these areas are considered concealed.

D. Minimum Mounting Height: Install exposed raceway and all other electrical equipment (e.g., lighting fixtures) with not less than 7 feet and 6 inches clear to finished floor unless indicated or approved otherwise, and excluding raceway and equipment mounted on walls.

E. Dimensions and Clearances: Field measure all dimensions and clearances affecting the installation of electrical work in relation to established datum, building openings and clearances, and work of other trades as construction progresses.

F. Rough-In Locations: Verify final locations for rough-ins with field measurements and requirements of actual equipment being installed.

G. Door Swings: Verify the swings of all doors before switch outlets or other electrical devices are installed. If necessary, relocate devices so they are not obstructed by doors when doors are open.

H. Ceiling Mounted Devices: The locations indicated on the architectural reflected ceiling plans take precedence over the electrical documents, in the event of conflict.

I. Install equipment according to manufacturer’s written instructions.

J. Install equipment, conduit, cable tray, hangers, and supports to withstand seismic forces for the seismic zone of the installation.

3.7 LAYOUT

A. General: Install electrical systems, materials and equipment level and plumb, and parallel and perpendicular to other building systems and components, where installed exposed.

B. Serviceability: Install electrical equipment and raceways, etc., to readily facilitate servicing, maintenance, and repair or replacement of components and so as to minimize interference with other equipment and installations.
C. Clearances: Prior to commencing work, verify that all electrical equipment will adequately fit and conform to the indicated and code required clearances in the spaces indicated on the Drawings. If rearrangement is required, submit plan and elevation drawings or sketches indicating proposed rearrangement for the Engineer’s approval. Do not rearrange without express written permission of the Engineer.

D. Right-Of-Way: When laying out electrical work, give priority in available space to steam and condensate lines, sanitary lines, drain lines, fire protection piping, and sheet metal duct work. Provide offsets as required to avoid conflicts. Resolve all conflicts before commencing installation.

3.8 MOUNTING HEIGHTS

A. General: Indicated heights are measured from the center of the device outlet box to finished floor or grade, unless indicated otherwise. Request instructions for mounting heights not indicated.

3.9 HOLES, SLEEVES, AND OPENINGS

A. General: Provide all holes, sleeves, and openings required for the completion of Division 26 work and restore all surfaces damaged to match surrounding surfaces. Maintain integrity of all fire and smoke rated barriers using approved firestopping systems. When cutting holes or openings, or installing sleeves, do not cut, damage, or disturb structural elements or reinforcing steel unless approved in writing by the Project Structural Engineer.

B. Conduit Penetrations: Size core drilled holes so that an annular space of not less than 1/4 inch and not more than 1 inch is left around the conduit. When openings are cut in lieu of core drilled, provide sleeve in rough opening. Size sleeves to provide and annular space of not less than 1/4 inch and not more than 1 inch around the conduit. Patch around sleeve to match surrounding surfaces.

3.10 FIRESTOPPING SYSTEMS

A. General: Install firestopping at all electrical raceway and cable penetrations through floor structures and interior walls or partitions, which are time-rated fire and/or smoke barriers.

B. Preparation: Prior to installation, verify that all penetrating elements and supporting devices are permanently installed and that surfaces which will be in contact with penetration seal materials are clean and free of dust, dirt, grease, oil, loose materials, rust or other substances.

C. Installation: Install firestop systems in accordance with UL approved design details and the manufacturer’s instructions. Install sleeves, conduits, and cables with required clearance spaces, allowing installation of sealing materials. Do not exceed the outside diameter of the sleeve, conduit, or cable by more than 1 inch or by less than 1/4 inch when making openings for penetrations. Install firestop systems so as to completely seal openings to prevent passage of smoke and water.

3.11 CUTTING AND PATCHING

A. General: Provide all cutting, drilling, chasing, fitting, and patching necessary for accomplishing the work of Division 26, which includes any and all work necessary to: uncover work to provide for the installation of ill-timed work; remove and replace defective work and work not conforming to the requirements of the Contract Documents; and install equipment and materials in existing structures, in addition to that required during the normal course of construction.

B. Comply with the cutting and patching requirements of Division 1.
C. Building Structure: Do not endanger the integrity of the building structure by cutting, drilling, or otherwise modifying any structural member without specific approval. Do not proceed with any structural modifications without written permission of the Project Structural Engineer.

D. Repairs: Repair any and all damage to work of other trades caused by cutting and patching operations using skilled mechanics of the trades involved.

3.12 WELDING

A. General: Where welding is required, such welding shall be performed in a skilled manner by certified welders. Verify that welds are free from cracks, craters, undercuts, and strikes, weld spatter, and any other surface defects. Clean and re-weld any welds deemed unacceptable in size or configuration. Do not weld to structural steel without prior written permission from the Project Structural Engineer.

3.13 ELECTRICAL DEMOLITION

A. General: Provide electrical demolition work as indicated and as required for removal and/or abandonment of systems, equipment, devices, etc., made obsolete by this Project and as required for demolition and remodeling by the other trades.

B. Existing Conditions: In general, existing electrical systems, equipment, and devices are not shown on the Drawings unless pertinent to the demolition and/or remodeling work. Existing electrical conditions, where indicated, are based on casual field observations and must be verified. Report any discrepancies to the Engineer before disturbing the existing installation.

C. Examination: Prior to bidding, examine the site to determine all actual observable conditions. No additional compensation will be granted on account of extra work made necessary by the Contractor’s failure to investigate such existing conditions.

D. Scheduling and Phasing: Coordinate demolition and changeover work with the other trades involved and with the Owner’s Representative.

E. Protection of Adjacent Materials: During execution of demolition work, primary consideration shall be given to protecting from damage, the building structure, furnishings, finishes, and the like, which are not specifically indicated to be removed. Existing items or surfaces to remain, which are damaged as a result of this work, shall be refinished, repaired, or replaced to the satisfaction of the Owner at the Contractor’s expense.

F. Patching: When electrical materials are removed, patch and finish walls, surfaces, etc., to match surrounding surfaces. Provide blank coverplates as required, etc. Materials used for patching shall be in conformance with the applicable sections of the Project Manual. Where materials are not specifically described, but required for proper completion of the Work, they shall be as selected by the Contractor subject to approval of the Engineer.

G. Inspection: Before commencing demolition work, carefully inspect the project site and become familiar with existing systems and conditions.

H. Items To Be Salvaged: Verify with the Owner, all systems, materials, and equipment which are to be salvaged and those which must be removed. The Owner reserves the right to salvage any or all existing electrical materials and equipment at the project site.

I. Disconnections: Disconnect all electrical devices and equipment as indicated and required. Disconnect electrical connections to mechanical and other equipment being removed by other trades.
J. Wiring Removals: Where existing electrical devices or equipment are indicated to be removed, remove all associated wiring. Remove all abandoned or dead wiring back to source.

K. Raceway Removals: Remove all abandoned raceways, boxes, supports, etc., where exposed and where they interfere with new work of any trade. Cut conduits flush with walls and floors, and cap.

L. Existing Electrical Work to Remain: Protect and maintain access to existing electrical work, which must remain. Reinstall existing electrical work disturbed.

M. Reconnections: Where electrical work in adjoining areas, or electrical work indicated to remain, becomes disconnected or affected by demolition work, reconnect circuits, etc., as required to restore original operation. Restoration work to comply with requirements for new work.

N. Existing Electrical Work to be Relocated: Disconnect, remove, reinstall and reconnect existing devices and equipment indicated to be relocated and where required to accommodate remodeling or new construction. Extend existing installations as required. Materials and methods used for relocations and extensions to conform to requirements for new work.

O. Shutdowns: All shutdowns to existing electrical services to be scheduled and approved, in writing, by the Owner’s Representative.

3.14 RACEWAY SYSTEMS

A. Raceway Types: Unless indicated otherwise, use raceway types as follows:
   1. Indoors, Concealed in Walls or Above Ceilings: EMT.
   2. Indoors, Exposed: Use rigid galvanized steel conduit below 10 feet above finished floor. EMT may be used above 10 feet.
   4. Outdoors, Below Grade: (Minimum 1 inch size). Schedule 40 rigid non-metallic conduit. Stub up using rigid galvanized steel elbows.
   5. Outdoors, Exposed: Rigid galvanized steel conduit.
   6. Flexible Steel Conduit: Use (in dry locations only) for connections to transformers, vibrating equipment, and equipment requiring minor adjustments in positions for final connections to recessed lighting fixtures and between outlet boxes in metal stud partitions.
   7. Liquid-Tight Flexible Steel Conduit: Use where flexible steel conduit connections are required in damp, wet, or oily locations, and for final connections to all motors and similar equipment.

B. Raceway Routing: As required by job conditions unless specific routes or dimensioned positions are indicated on the Drawings. Install tight to slabs, beams, and joists wherever possible. Route exposed conduit, and conduit installed above ceilings, parallel or perpendicular to walls ceilings and structural members. Install to maintain minimum headroom and to present a neat appearance. Run parallel raceways together with bends made from same center line. Verify exact locations of all raceways, pull boxes, and junction boxes. Resolve any conflicts before installation.

C. Raceway Installation: Cut conduit ends square using saw or pipe cutter and ream each cut end smooth. Carefully make all conduit bends and offsets so that the inside diameter of pipe is not reduced. Make bends so that legs are in the same plane. Make offsets so that legs are in the same plane and parallel. Protect stub-ups from damage, and carefully rebend when necessary.
D. Fittings: Make up all raceway fittings tight so that final installation of raceway, fittings and enclosures constitutes a firm mechanical assembly and a continuous electrical conductor. Where required, provide bonding jumpers to assure electrical continuity.

E. Protection: Protect all raceways, enclosures, and equipment during construction to prevent entry of concrete, debris and other foreign matter. Free clogged conduits of all obstructions, or replace, prior to pulling wire. Do not pull wire within buildings until buildings are completely enclosed.

F. Boxes: Install all outlet, pull, and junction boxes rigidly, plumb, and level. Support and secure boxes independently from conduits terminating at box. Install all boxes so as to be accessible and so that covers may be easily removed.

G. Handholes: Provide as indicated, installed plumb and level. Where not indicated, install every 200 feet at a minimum.

H. Conduit Seals: Install conduit seal for each conduit penetrating an exterior building wall below grade (unless penetration is below lowest building floor slab) and elsewhere as indicated, and so as to achieve a sealed watertight installation.

I. Pull Strings: Provide pull strings in all spare conduits.

3.15 CONDUCTORS - 600 VOLT AND BELOW

A. Minimum Conductor Size: All branch circuit wiring shall be minimum #12 AWG. All control circuit wiring shall be minimum #14 AWG unless indicated otherwise. Provide larger sizes as indicated or required.

B. Branch Circuit Conductor Sizes: Provide branch circuit conductor sizes as indicated on the panelboard schedules, plans, or elsewhere. Neutral conductor size to match phase conductors unless indicated otherwise. Provide branch circuit switch legs and travelers as required for the switching indicated.

C. Equipment Grounding Conductor Required: For each branch circuit and feeder run, provide an equipment grounding conductor for continuous length of run, sized per NEC 250-122 (minimum), larger if so indicated.

D. Feeders: Provide feeder conductor sizes and quantities as indicated.

E. In Raceway: Install all wiring in conduit or other specified raceway unless indicated otherwise.

F. Terminations: Furnish and install terminations including lugs (if necessary) to make all electrical connections indicated or required. Make connections and terminations for all stranded AWG conductors using crimp, clamp, or box-type connectors and terminators. Enclose all strands of stranded conductors in connectors, and lugs.
G. **Color:** Conductors #10 and smaller shall be factory color-coded by integral pigmentation with a separate color for each phase and neutral. #8 and larger shall have stripes, bands, hash marks, or color pressure-sensitive plastic tape. Color code all branch circuit and feeder conductors as follows:

1. **208/120 Volts:**

<table>
<thead>
<tr>
<th>PHASE</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Black</td>
</tr>
<tr>
<td>B</td>
<td>Red</td>
</tr>
<tr>
<td>C</td>
<td>Blue</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
</tr>
</tbody>
</table>

2. **480/277 Volts:**

<table>
<thead>
<tr>
<th>PHASE</th>
<th>COLOR</th>
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</thead>
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<tr>
<td>A</td>
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<tr>
<td>B</td>
<td>Orange</td>
</tr>
<tr>
<td>C</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>Gray</td>
</tr>
</tbody>
</table>

3. **Equipment Grounding Conductors:** Green

H. **Phase Arrangement:** Arrange phases in all electrical equipment as follows:

1. A, B, C: Front to Rear.
2. A, B, C: Top to Bottom.
3. A, B, C: Left to Right when facing established front of equipment.

I. Provide conductors with not less than 90 DegC rated insulation when branch circuit wiring is attached to high temperature light fixtures (e.g., fluorescent and HID), boilers, incinerators, ovens, ranges, kitchen exhaust fans, other heat-producing equipment, and “100 percent rated” overcurrent protective devices. Use special higher temperature wire as required for connection to specialty equipment as required by equipment manufacturer.

3.16 **EQUIPMENT CONNECTIONS**

A. Connect complete, all equipment requiring electrical connections, furnished as part of this Contract or by others unless indicated otherwise.

B. **Equipment Variations:** Note that equipment sizes and capacities as shown on the Contract Documents are for bidding purposes and as such may not be the exact unit actually furnished. Contractor shall anticipate minor variations in equipment and shall include in his Bid all costs required to properly connect the equipment actually furnished.

C. **Verification:** Obtain and review shop drawings, product data, and manufacturer’s instructions for equipment furnished by others. Examine actual equipment to verify proper connection locations and requirements.

D. **Coordination:** Sequence electrical rough-in and final connections to coordinate with installation and start-up schedule and work by other trades.
E. Rough-In: Provide all required conduit, boxes, fittings, wire, connectors, miscellaneous accessories, etc., as necessary to rough in and make final connections to all equipment requiring electrical connections. In general, motors and equipment shall be wired in conduit to a junction box (or safety switch) near the unit, and from there to the unit in flexible metal or liquid-tight flexible steel conduit.

F. Connections: Provide properly sized overload and short circuit protection for all equipment connected, whether furnished under this Contract or by others. Verify proper connections with manufacturer’s published diagrams and comply with same. Verify that equipment is ready for electrical connections, wiring, and energization prior to performing same.

G. Control Wiring: Provide all control wiring to remote devices or equipment as indicated or required. Modify equipment control wiring, install or disconnect jumpers, etc., as required.

3.17 HANGERS AND SUPPORTS

A. General: Rigidly support and secure all electrical materials, raceway, and equipment to building structure using hangers, supports, and fasteners, suitable for the use, materials and loads encountered. Provide all necessary hardware.

B. Overhead Mounting: Attach overhead mounted equipment to structural framework or supporting metal framework. Do not make attachments to steel roofing, steel flooring, or ceiling mineral tile.

C. Wall Mounting: Support wall mounted equipment by masonry, concrete block, metal framing, or sub-framing.

D. Exterior Walls: Mount all electrical equipment located on the interior of exterior building walls at least 1 inch away from wall surface using suitable spacers.

E. Structural Members: Do not cut, drill, or weld any structural member.

F. Independent Support: Do not support electrical materials or equipment from other equipment, piping, ductwork, or supports for same.

G. Temporary Conditions: Do not attach to or support electrical work from removable or knockout panels or temporary walls or partitions.

H. Raceway Supports: Rigidly support all raceway with maximum spacings per NEC and so as to prevent distortion of alignment during pulling operation. Use approved hangers, clamps, and straps for individual runs. Do not use perforated straps or tie wires. Where multiple parallel raceways are run together, use trapeze type hanger arrangement made from U-channel and accessories, suspended by threaded rods, and allow at least 25 percent spare capacity for future installation of additional raceways. Rigidly anchor vertical conduits serving floor-mounted or “island” type equipment mounted away from walls with metal bracket or rigid steel conduit extension secured to floor.

I. Miscellaneous Supports: Provide any additional structural support steel brackets, angles, fasteners, and hardware as required to adequately support all electrical materials and equipment.

J. Seismic restraints and supports: Provide as indicated and/or as required per seismic zone indicated.

3.18 ELECTRICAL IDENTIFICATION

A. General: Locate nameplate, marking, or other identification means on outside of equipment or box front covers when above ceilings and when in mechanical or electrical equipment rooms or other unfinished
areas, and on inside of front cover when in finished rooms/areas. Use Contract Document designations for identification unless indicated otherwise.

B. Nameplates: Provide nameplate engraved with equipment designation for each safety switch, panelboard, transformer, motor starter, and all other electrical cabinets, etc.

C. Underground Warning Tape: During trench backfilling for each underground electrical, telephone, signal, and communications line, provide a continuous underground warning tape located directly above line at 6 to 8 inches below finished grade.

D. Marking Pen Labeling: Mark each junction and pull box indicating source designation and circuit number(s) for the enclosed conductors.

E. Wire Tags: For power circuits, apply wire tag indicating appropriate circuit or feeder number to each conductor present in distribution panel and panelboard gutters, and to each conductor in pull and junction boxes where more than one feeder or multi-wire branch circuit is present. Where only a single feeder or multi-wire branch circuit is present, box cover labeling and conductor color coding is sufficient. For control, communications, and signal circuits, apply wire tag indicating circuit or termination number at all terminations and at all intermediate locations and boxes where more than one circuit is present.

F. Panelboard Circuit Directories: At completion of project, accurately complete each panelboard circuit directory card, identifying load served or “spare” or “space” for each circuit pole. When modifying, adding or deleting circuits at an existing panelboard, update the existing (or provide new) circuit directory card to accurately reflect final conditions.

G. Abandoned Equipment: Label all abandon equipment as “Abandon as of ______.” For conduits and conductors, include opposite end location.

3.19 GROUNDING

A. General: Provide all system and equipment grounding as indicated and required by the NEC.

B. Equipment Grounding: Provide a green equipment grounding conductor, sized per NEC 250-122 (larger if so indicated), with each feeder and branch circuit run.

C. Provide exothermic welded connections where indicated.

3.20 DRY TYPE TRANSFORMERS

A. Mounting: Install transformers on floors or walls, or suspend from building structure as indicated with mounting provisions, supporting means and methods as required for the weights and types of building construction encountered, and in compliance with all building and seismic codes. All floor mounted transformers to be set on 4-inch high concrete housekeeping pads.

B. Conduit Connections: Make all conduit connections to transformer cases using flexible metal conduit.

C. Ventilation Openings: Do not obstruct transformer ventilation openings.

D. Taps: Set transformer taps for proper secondary voltage.
3.21 PANELBOARDS

A. Secure rough-in boxes to building structure or steel framing, independent of conduits. Install with top of cabinet at 7 feet 0 inches above floor but with minimum 8-inch clearance above floor unless so doing would exceed maximum 6-foot 6-inch disconnect height allowed by NEC.

B. Cover all unused overcurrent protective device spaces.

3.22 SAFETY SWITCHES

A. Mount securely at the location indicated on the Drawings.

B. Provide fuses as required.

3.23 INDIVIDUAL MOTOR CONTROLLERS

A. General: Make all connections to motors and control equipment complete, and verify that equipment is in proper operating order. Connect power to motors for correct direction of rotation. Verify nameplate ratings of all motors. Report any deviations or discrepancies.

B. Overcurrent and Overload Protection: Provide fuses (where indicated or required) and overload elements sized in accordance with the ambient temperature, the actual motor nameplate full load amperes, and service factor.

C. Power Wiring: Unless indicated otherwise, provide all required power wiring from indicated power source to each motor controller and from each motor controller to respective motor.

D. Control Wiring: Provide as indicated. Unless indicated otherwise, use No. 14 AWG wire for all control circuits. For circuits longer than 200 feet and for 120 volt motors, use No. 12 AWG wire.

3.24 CHECKOUT, TESTING, AND ADJUSTING

A. General: Provide testing equipment, materials, instruments, and personnel to perform all test procedures and adjustments required by the Contract Documents and/or deemed necessary by the Engineer to establish proper performance and installation of electrical systems and equipment. All test instruments to be accurately calibrated and in good working order.

B. Scheduling: Schedule tests at least three days in advance, and so as to allow Engineer and Owner representative(s) to witness the test, unless directed otherwise. Do not schedule tests until the system installation is complete and fully operational unless indicated or directed otherwise.

C. Manufacturer’s Authorized Representatives: For all new and modified systems and equipment, arrange and pay for the services of the manufacturer’s authorized representative(s) to be present at time of equipment or system start-up, to supervise the start-up, and to conduct and/or certify all required testing and adjusting.

D. Test Reports: Submit test reports neatly typewritten on 8-1/2-inch-by-11 inch sheets indicating system or equipment being tested, methodology of testing, date, and time of test, witnesses of test, and test results. Submit test reports in three (3) copies to the Engineer for review within five (5) days after test is performed, and include a copy with the appropriate operation and maintenance data.
E. Correction/Replacement: After testing, correct any deficiencies, and replace materials and equipment shown to be defective or unable to perform at design or rated capacity. Retest without additional cost to the Owner or Contract. Submit finalization report indicating corrective measures taken and satisfactory results of retest.

3.25 SYSTEMS DEMONSTRATION

A. Instruct the Owner’s representative(s) in the start-up, operation, and maintenance of all electrical systems and equipment in accordance with Division 1 and as requested by the Owner’s Representative.

3.26 CLEANING AND TOUCH-UP PAINTING

A. Perform cleaning required by Division 1.

B. General: Periodically remove from the project site, all waste, rubbish, and construction debris accumulated from construction operations, and maintain order. The premises shall be left clean and free of any debris and unused construction materials prior to final acceptance.

C. Electrical Equipment: Remove all dust, dirt, debris, mortar, wire scraps, rust, and other foreign materials from the interior and exterior of all electrical equipment and enclosures, and wipe down. Clean accessible current carrying elements and insulators prior to energizing.

D. Touch-Up Painting: Restore and refinish to original condition, all surfaces of electrical equipment scratched, marred, and/or dented during shipping, handling, or installation. Remove all rust, and prime and paint as recommended by the manufacturer.

END OF SECTION
SECTION 260523 – MOTOR POWER AND CONTROL WIRING

PART 1 – GENERAL

1.1 SUMMARY

A. Description of Work: Provide all power and control wiring for and make connections to motors and motor control equipment.

B. Motors: In general, motors are provided under Division 26.

C. Motor Control Equipment: In general, motor control equipment is provided under Divisions 22-23, and installed and wired under Division 26. Exceptions are as indicated on the Drawings and specified herein.

D. Motor Control Equipment: In general, motor control equipment is provided, installed, and wired under this Division. Exceptions are as indicated on the drawings and specified herein.

E. Coordinate with Divisions 22-23 so that:
   1. There is no duplication of services or materials provided.
   2. Motor controllers provided are specifically designed for and fully compatible with each motor supplied by Divisions 22-23 in every aspect.

1.2 RELATED DOCUMENTS

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

B. All Division 26 Specifications shall apply to this Section.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1.

B. Wiring Diagrams: For each motor provide computer generated power wiring and control ladder diagrams specifically developed for this project.

1.4 QUALITY ASSURANCE


PART 2 – PRODUCTS

2.1 GENERAL

A. Equipment and materials as specified elsewhere in Division 26 or as indicated on the Drawings.
PART 3 – EXECUTION

3.1 GENERAL

A. Connections: Make all connections to motors and control equipment complete and leave equipment in proper operating order. Connect power to motors for correct rotation. Verify nameplate ratings of all motors. Report any deviations or discrepancies.

B. Coordination: Coordinate with Divisions 22-23 as required.

3.2 POWER WIRING

A. General: Unless indicated otherwise, provide all required power wiring from indicated power source to each disconnect, controller, and motor, as required.
   1. If wire size is not indicated, minimum size will be as indicated in NEC Article 430.

3.3 CONTROL WIRING

A. General: Automatic temperature control wiring for HVAC equipment shall be provided under Division 23. Wiring from motor controllers to remote control stations, and interlock wiring is to be provided under Division 26.

B. Coordination: Provide all control wiring as indicated on the Division 26 motor control notes, diagrams or elsewhere. Coordinate all control interfaces with Division 23.

C. Wire Size: Unless indicated otherwise use No. 14 AWG wire for all control circuits. For circuits longer than 200 feet use No. 12 AWG wire.

D. Control Circuit Power: Connect all control circuitry for motors so that when the circuit to the motor is disconnected, the control power is also disconnected. When control power is from a source other than the motor’s power source, install an auxiliary control power interlock switch integral with the motor’s or motor controller’s disconnect. If the equipment design does not allow this, install a lockable, labeled control power disconnect immediately adjacent to the motor disconnect.

E. Installation: Install all control wiring in conduit. Neatly group, tie and strap in place all control wiring, and terminate at labeled terminal strips.

3.4 ROOF-TOP EQUIPMENT

A. Install wiring to roof-top equipment (e.g., power roof ventilators) in such a way that all conduit and wiring will be covered by unit. Seal conduit roof penetrations as indicated in the Contract Documents and Specifications.

END OF SECTION