Rancho Santiago Community College District
Santa Ana College Science Center

1530 W. 17th St., Santa Ana, CA

Specifications

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Volume Two
Divisions 21 - 23

Architecture | Engineering | Planning

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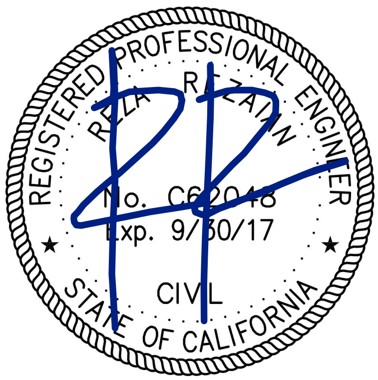

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SECTION 211313
AUTOMATIC SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. Furnish all materials and labor for the detailed design and installation for (a) new fire sprinkler (wet-pipe) system(s), hereafter referred to as the "System(s)" in complete compliance with this Specification for the Santa Ana College Science Center project in Santa Ana, California.

B. The contract drawings and this Specification define the scope of work for the project. The contract drawings are intended to be engineered working plans only in accordance with NFPA 13 Chapter 22, and the Contractor's responsibilities are defined herein. Where conflicts occur between the Specification and the contract drawings, the bidder is instructed to request clarification prior to bidding. In general, should a conflict occur, this specification takes precedence over the contract drawings.

C. The work shall be subject to the terms and conditions contained in the "Construction Contract," agreement between the Contractor and the Owner.

All applicable fees, taxes, and permit costs for all work contained in this specification section shall be included in this Contractor's base bid.

D. Contractor shall be responsible for the review and compliance with this Specification section and the DSA approved plans and calculations. All work shall be performed in accordance with these Specifications and good engineering and installation practice. Modifications to these Specifications will NOT be accepted without the expressed written approval of Owner, Owner's Representative, and/or Owner's Insurance Carrier; herein referred to as the "Owner". It is Contractor's responsibility to document the required approvals of any such modifications prior to the execution of work. It is the Contractor's responsibility to document the intent to modify the approved design and document all required approvals of any such modifications deemed "major changes" based on DSA Policy PL 10-01 Section 4.3.1 prior to bid and prior to the execution of work. Change of the design by the contractor as outlined in Section 4.3.1 will NOT be accepted without the expressed written approval and coordination with the Owner.

E. It is the Contractor's responsibility to receive approval of any changes from the design drawings deemed "minor changes" as outlined in Section 4.3.2 of DSA Policy PL 10-01 using the DSA change order process and appropriate addenda. For changes to the design drawings which alter the design of the system and require a Field Change Document (FCD) to be prepared, the preparation of the FCD shall be the responsibility of the Contractor and review will be provided by the Engineer of Record. Changes or modifications which do not modify the design of the system (such as addition of bracing or changes in specified material) shall be addressed using a DSA change order and shall require approval of the Owner.

F. Contractor shall field verify all site conditions and information contained on the contract drawings and is responsible for the complete design and installation of the system(s) in accordance with the specifications. The contract drawings may not show all information necessary for installation of the system(s), but are intended to be used by Contractor for the purpose of preparing a bid. The contract drawings indicate the following:

1. Hydraulically calculated pipe routing and sizes.
2. Approximate routing and elevations of overhead piping.
3. Types and minimum quantities of sprinklers and valves.
4. Location of the new riser(s) for the System(s), and major points on the system, such as the fire department connection(s).

5. NFPA Hazard Classifications.
6. Additional information as required in the DSA AFSS Checklist.

G. There shall be no impairments to any of the adjoining building system(s) in any way due to the work provided for in this specification.

1.2 INTENT OF SPECIFICATIONS

A. The work performed pursuant to these specifications is to be complete in every respect, resulting in the System(s) installed in accordance with the applicable codes, standards, manufacturers' recommendations, and Underwriters Laboratories Inc. (UL) listings and/or Factory Mutual (FM) Global approval.

B. Upon completion of this work, and as a part of this contract, Contractor shall provide Owner with:

1. Complete information and "as-built" record drawings describing and depicting the entire system as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system at a future date.
2. Complete documentation of system(s) testing and Authority Having Jurisdiction (AHJ) acceptance.

C. Certification that Contractor's work has been inspected and tested, is installed entirely in accordance with the applicable codes, standards, manufacturers' recommendations and UL listings and/or FM approvals, and is in proper working order. Contractor shall use "Contractor's Material and Test Certificate(s)" as required by NFPA codes.

1.3 WORK INCLUDED

A. General: Furnish all materials and labor for the design, installation, and testing of new sprinkler system(s) throughout the new building in accordance with all applicable codes and requirements of this Specification.

B. Provide personnel to inspect and verify piping and sprinkler locations as indicated in the bid drawings. The contractor is responsible for any pipe routing changes, including offsets, required to install the new system(s).

C. Provide personnel to inspect and verify piping and sprinkler locations as indicated in the bid drawings. The contractor is responsible for any pipe routing changes, including offsets, required to install the new systems.

D. Sprinkler: Furnish and install all components necessary for the automatic sprinkler system(s) to result in (a) fully operational system(s). Provide appropriate water flow (pressure switch or vane type) and valve supervisory (tamper) to provide all monitoring of the System(s). Interface to the new fire alarm system shall be completed by the Fire Alarm Contractor, as specified in the Fire Alarm Specification

E. Sprinkler Zones – Where shown on the drawings and/or detailed in the specifications, fire sprinkler system zoning and alarms shall correspond to alarm and detection and/or smoke control zones at a minimum, one sprinkler zone is required for each full floor.

F. Water supply for the building will be served from the existing water main as shown on the drawings. Flow test information for the city water supply is listed on the drawings.

G. Standpipes – Provide Class I, manual wet standpipes at every required stair in the new Building as required to comply with Chapter 9 of the California Building Code and NFPA 14 (2013 edition with State of California ammendments) requirements. Hose connections shall be provided within enclosure/cabinet where indicated by Architect and/or Owner.

H. Standpipe Drain Riser: Provide two (2) inch drain riser at each standpipe in accordance with NFPA 14.

I. Drains: Provide all piped connections to the exterior of the building necessary to drain and test the sprinkler and standpipe systems. Drains shall terminate at the exterior of the building, or, when and where approved by Owner, at an interior drain capable of handling full flow conditions.

J. Provide updated record (as-built) drawings and hydraulic calculations to the Orange County Fire Authority (OCFA) and the Owner's Consultant for final approval.

K. Shields: Install shields where necessary to protect electrical equipment from sprinkler discharge. Shields shall be such that water spray from sprinklers is shielded from the intended equipment only. Shields shall not completely block water spray over the remainder of the area to be protected. Coordinate with electrical drawings for these locations.

L. Valves: Furnish and install all system control valve(s), main and inspector's test drain valves, and other appurtenances as required for a fully operable system. All system control valves shall be equipped with tamper switches for electronic supervision.

M. Painting: Painting of pipe and fittings shall be included throughout the building where the piping and fittings are exposed in public areas. The contractor must coordinate with the Owner regarding color matching and adjacent architectural features. This Contractor shall include one coat of latex primer, and one finished coat of latex paint. Pipe and fittings shall be painted red in mechanical and non-public areas (unless otherwise indicated on building plans or as directed by Owner) to indicate fire service use.

N. Submittals: Prepare and submit shop drawings, product data sheets, hydraulic calculations, record drawings and other submittals required herein. Work is not to proceed until all required submittals have been approved by Owner and all AHJ. Contractor shall be responsible for the submission of the required materials to the owner and all approving authorities.

O. Tests: Each new sprinkler and/or standpipe system shall be tested in accordance with the requirements of NFPA 13 and NFPA 14, AHJ and the Owner. The Sprinkler contractor shall also attend all fire alarm tests to aid in testing sprinkler system monitoring devices. Contractor shall be responsible for carrying out all required tests. Separate tests may be required by the Owner and AHJ.

P. Approvals: Obtain all approvals required for the work of this section from all AHJ and Owner.

Q. Fees: Pay all fees required to obtain permits, inspections and final approval of the work in this section.

R. Coordination: Coordinate work with all other trades working on the project, and with the other fire protection system(s) specified elsewhere.

S. Unit Additions: Contractor shall provide unit pricing for any additional work or services as described in the Bid Format sheets.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Underground Water Supply Piping: Water supply piping to (a) finished standard cast iron companion flange(s) left plumb and level, six (6) inches above the finished floor at point(s) shown on the bid drawings and documents. Size of flange(s) and underground supply mains are as shown. Project point of connection shall be 6-inches above the finished floor of the ground level in the interior the building.

B. Post Indicator Valve (PIV) – a post indicator valve for the underground feed to the building shall be provided by others as indicated on the civil drawings.

C. Alarms: Wiring and connection to sprinkler system alarm and supervisory devices shall be provided by Fire Alarm Contractor as detailed in the Fire Alarm and Detection Specification.

D. Drains: Floor drains and other facilities for receiving discharge from sprinkler and standpipe system drains.

1.5 QUALITY ASSURANCE

A. All work shall conform to the requirements of the applicable editions and portions of the National Fire Protection Association (NFPA) Standards, locally adopted codes, including:

1. Title 24, Part 2, California Building Code (CBC) 2013 edition with City of Santa Ana and OCFA amendments
2. Title 24, Part 3, California Electrical Code (CEC) 2013 edition with City of Santa Ana amendments
3. Title 24, Part 9, California Fire Code (CFC) 2013 edition with City of Santa Ana and OCFA amendments
4. NFPA 13, 2013 edition, "Standard for the Installation of Sprinkler Systems" with State of California amendments.
5. NFPA 14, 2013 edition, "Standard for the Installation of Standpipe and Hose Systems" with State of California amendments.
6. NFPA 24, 2013 edition, "Private Fire Service Mains and Their Appurtenances" with State of California amendments.
7. NFPA 72, 2013 edition, "National Fire Alarm Code" with State of California amendments.

All work and materials shall conform to all Federal, State, and local codes and regulations governing this installation including all parts of Title 24 statewide California codes.

B. Code Conflicts: Should conflicts exist between the referenced NFPA Standards, Federal, State or local codes and this specification, it shall be Contractor's responsibility to bring the conflict to the attention of Owner for resolution. The contractor shall not attempt to resolve code conflicts with the local authority, independent of Owner. In general, in the event of a conflict, the most stringent of the requirements will apply.

C. Permit Fees: Contractor shall be responsible for filing all documents, paying all fees and securing all permits, inspections and approvals necessary for completing the scope of the work in this section.

D. Equipment: All devices, systems, equipment and materials furnished and installed shall be new and shall be submitted for approval by Owner. All sprinklers, pipe, fittings, hangers, valves, and other materials and equipment shall be UL Listed and/or FM approved for their intended use. All shall be acceptable to the AHJ when such agencies have listings of acceptable equipment.

E. Fittings: Fittings may be of the flanged, threaded, or grooved type. Welded outlets on cross-mains for riser nipples and/or branch lines, and for sprinkler outlets on branch lines will be permitted. All shall be UL Listed and/or FM approved for their intended use. The use of plain-end fittings to join steel pipe is not permitted.

F. Contractor Requirements: Contractor shall:

1. Hold all licenses and obtain all permits necessary to perform work of this type in the State of California. Copies of Contractor's licenses shall be provided with bid submittal.
2. Be regularly engaged, for the past five years in the design, installation, testing and servicing of automatic sprinkler systems for buildings of this type.
3. Contractor's site supervisor will be at the job site at all times when work is actively in progress.

1.6 SPRINKLER SYSTEM DESIGN CRITERIA

A. Densities: Hydraulically designed and calculated sprinkler system(s) shall be installed in accordance with the construction documents. The system(s) has (have) been designed to produce discharge densities of:

1. 0.10 gpm/square foot over the hydraulically most remote 1,500 square feet in spaces designated as Light Hazard Occupancies.
2. 0.15 gpm/square foot over the hydraulically most remote 1,500 square feet in spaces designated as Ordinary Hazard Group 1 Occupancies.

3. 0.20 gpm/square foot over the hydraulically most remote 1,500 square feet in spaces designated as Ordinary Hazard Group 2 Occupancies.

B. Hose stream requirements: The calculations shall include a 100 gpm inside hose stream at the hose valve closest to the floor control valve assembly. The combined (inside and outside) hose stream for the calculations shall be 250 gpm.

C. Provide sprinklers throughout the facility including under ducts, stairs, and obstructions as required by NFPA 13. A unit additional price for sprinklers under ducts, stairs, or other obstructions wider than 4 feet required but not shown on the construction documents in excess of 25 shall be provided at the unit additional cost specified by the contractor in the bid format sheets. Base bid shall include 10 sprinklers in additions to those indicated in the drawing.

D. All branch line piping shall be minimum 1" nominal size. Branch line piping in gridded systems shall be minimum 1¼" nominal size. Threaded outlets on branch lines supplying sprinklers shall match the sprinkler threads, but shall be 1" NPT if supplying a sprig or drop.

1.7 SUBMITTALS

A. Shop Drawings: Contractor will be authorized to start the project or portions of the project when the shop drawings for the work are received, reviewed and approved by Owner and all AHJ. Installation prior to these approvals shall be at this Contractor's risk.

1. Shop drawings shall show all of the information required by the applicable NFPA codes for working plans as well as DSA AFSS Submittal Guidelines.
2. Shop drawings shall include a drawing legend sheet identifying:
    a. All symbols used on the drawings, by type of device or equipment, manufacturer and manufacturer's part number. This information shall correspond to the manufacturer's catalog data sheets and installation manuals.
    b. All conventions, abbreviations and specialized terminology used on the drawings, as necessary to understand and interpret the information contained therein.
    c. A complete drawing list identifying all drawings in the shop drawing package by title, drawing number and Specification cross reference.
3. Shop drawings shall be single line or architectural floor plan drawings, drawn to 1/8-inch equals 1 foot scale or larger (i.e., 1/4-inch, etc.), showing a key plan and all other information required by the applicable NFPA codes for shop drawings.

B. Product Data: Contractor shall submit a product data submittal with the shop drawings. Manufacturers' Data Sheets shall show the type and model of all equipment or material proposed. This information shall include type of pipe, hangers, valves, pipe fittings/joining methods, air compressors, releasing panels, detection equipment, sprinklers, waterflow devices, supervisory devices, fire department connections, escutcheons, and signage. When a Data Sheet shows more than one product, the specific proposed product shall be clearly indicated by arrows or other suitable means. All manufacturers' data sheets shall clearly show all UL listings and/or FM approvals for each product submitted.

C. Contractor shall provide hydraulic calculations in accordance with the requirements of NFPA 13, showing that the pipe sizes provided will produce adequate performance. A minimum safety factor of 10 psi or 10%, whichever is greater, of the available pressure at the required system flow (including all required hose stream demands) shall be demonstrated in the hydraulic calculations.

D. Four sets of shop drawings, product data sheets, and hydraulic calculations as described in parts A, B and C shall be submitted to Owner for review. Only complete submittals containing all required information for all work required in this section will be reviewed. Incomplete submittals will be returned to Contractor without being reviewed.

E. All drawings and diagrams shall be prepared on drawing sheets of uniform size, 30 by 42 inches minimum, and shall contain no extraneous information. Marked up electrical, HVAC, or similar drawings or copies of catalog data sheets are not acceptable in lieu of the required drawings or diagrams. All other information required for this submittal shall be submitted in one or more appropriately labeled (i.e., Contractor's name, project, submittal name/description and date) and indexed 3-ring binders.

F. All Drawings and diagrams shall include Contractor's title block, complete with drawing title, Contractor's name, address, date including revisions, and preparer's and reviewers initials. All drawings and diagrams shall be reviewed and stamped as required by the AHJ.

G. Samples: Within 30 days of authorization to proceed, Contractor shall submit to Owner for approval, samples of all types of proposed sprinklers, including types of finishes available and a complete list of where each type and finish will be installed.

H. Prior to start of installation, Contractor shall submit copies of all permits and approvals to Owner necessary to conduct this work. A minimum of one complete set of such permits and approvals shall be kept by Contractor at the job site and shall be available for review.

I. Contractor shall provide Owner with one copy of all documents that are reviewed and approved by the AHJ and/or local code authorities. These documents shall include, but not be limited to, the following:

   1. Site inspection forms
   2. Shop drawings
   3. Final inspection forms
   4. Workers compensation insurance

   All documents shall include all required approval stamps, signatures or other information necessary to properly certify that the installation has been reviewed and accepted by the AHJ.

J. Operation and Maintenance (O&M) Manual: The Contractor shall provide Owner with an indexed 3-ring binder containing:

   1. 11" x 17" reduced copies of the ‘as-built’ record drawings required below (Final submittal only).
   2. Manufacturers’ catalog data sheets and installation manuals.
   3. Copy of REG 4 testing procedures.
   4. Copy of all test certificates and approvals.
   5. A list of recommended spare parts and summary of spare parts provided.
   6. A service directory, including a list of Contractor’s contact names and telephone numbers for service on the system, including emergency service as required elsewhere in these Specifications.

K. Draft O&M Manual: Within 30 days following the notice of authorization to proceed, Contractor shall submit to Owner three copies of the draft manual for approval, excluding test certificates and drawings. The draft manual will be reviewed for required content and approved or disapproved on that basis. Upon completion of the project, Contractor shall revise the approved, preliminary manual to reflect the system as installed and to coordinate the testing and maintenance schedule with the approved Contractor testing protocols. Any and all assigned fire protection device numbers shall also be indicated on Contractor's record drawings.

L. Final O&M Manual: Within 30 days of the completion of the work, two final copies of the approved manual with reduced drawings and test certificates shall be delivered to the Owner.

M. Record Drawings: Contractor shall provide and maintain on the site an up-to-date ‘as-built’ record set of approved shop drawing prints which shall be marked to show each and every change made to the sprinkler system from the original approved shop drawings. This requirement shall not be construed as authorization to deviate from or make changes to the shop drawings approved by Owner without written instruction from Owner in each case. These drawings shall be maintained in a current condition at all times and shall be made available for review immediately upon request during normal working hours throughout the installation.

N. Upon completion of the ‘as-built’ record drawings and before final approval, one set of reproducible ‘as-built’ record drawings shall be delivered to Owner. Upon approval by Owner, two sets of final record drawings shall be furnished to Owner. In addition, a record set of drawings shall be transmitted to Owner in the latest version of AutoCAD electronic format with any applicable executable, unarchiving files.

O. If Contractor's submittals, upon review by Owner, do not conform to the requirements of these specifications, Contractor shall be required to resubmit with modifications, within ten (10) working days of receipt of Owner's notification to Contractor. Contractor shall be responsible for Owner's expenses for subsequent review of rejected submittals that were necessitated by Contractor's failure to make the requested modifications. Such extra fees shall be deducted from payments by Owner to Contractor.

1.8 WARRANTY AND EMERGENCY SERVICE

A. Contractor shall warrantee all materials and workmanship for a period of two (2) years beginning with the date of final acceptance of Contractor's completed installation by Owner. Contractor shall be responsible during the design, installation, testing and warranty periods for any damage caused by Contractor (or its subcontractors) or by defects in Contractor's (or its subcontractors') work, materials, or equipment.

B. Emergency Service: During the installation and warranty period, Contractor shall provide emergency repair service for the sprinkler system(s) within four (4) hours of a request by Owner for such service. This service shall be provided on a 24-hour per day, seven days per week basis.

1.9 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts and special tools shall be provided to Owner prior to final acceptance, and shall be provided for each system riser location.

B. Spare Parts: Contractor shall install UL listed and/or FM approved spare sprinkler cabinets containing a minimum quantity of sprinklers, of each type, finish and temperature rating used in accordance with the requirements of NFPA 13, but not less than ten (10) spare sprinklers. Contractor shall provide two (2) sets of sprinkler wrenches compatible with each type of sprinkler provided in each cabinet. The cabinets shall be installed near the system riser(s) at location(s) approved by Owner. Contractor shall provide as many sprinkler cabinets as necessary to accommodate the required number of spare sprinklers, but a minimum of one spare cabinet per sprinkler riser location shall be provided.

C. Special Tools: Contractor shall supply Owner with two complete sets of special tools and equipment necessary to perform routine maintenance on the sprinkler systems.

1.10 FINAL ACCEPTANCE

A. Date of Final Acceptance will be established by Owner and shall be based on acceptance of the installation and required approved documentation by Owner and AHJ.

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment and system components furnished and installed shall be new and of first quality, and be listed by Underwriters Laboratories Inc. (UL), and/or approved by Factory Mutual (FM) for their intended use. All such equipment and system components shall be installed in accordance with the respective UL listings, FM approvals and California State Fire Marshal approved. All materials shall be acceptable to the Owner and the AHJ.

2.2 PIPE AND FITTINGS - GENERAL

A. Pressure ratings: Pressure ratings of all fittings shall meet or exceed maximum working pressures available within the system.

B. Corrosion protection: All piping and hangers, where exposed to the weather or installed in a corrosive atmosphere, shall be protected against corrosion. Piping and hangers in such areas shall be stainless steel and/or hot dipped galvanized. Piping having an external only galvanized finish in such areas is unacceptable.

2.3 ABOVEGROUND PIPING COMPONENTS

A. Pipe Sizes 2.5 inches (65 mm) and Larger.

1. Piping shall be ASTM A-53/A-135/A-795, Weight Class STD (Standard), Schedule 40 (except for Schedule 30 for pipe sizes 8 inches (200 mm) and greater in diameter), Type E or Type S, Grade A; black steel pipe. Steel pipe shall be joined by means of flanges welded or screwed to the pipe, threaded fittings, or grooved couplings only. Piping shall not be joined by welding or weld fittings.
2. Thinwall Pipe: Schedule 10 Pipe meeting ASTM A-53, A-135 or A-795 requirements with grooved pipe couplings and fittings. Grooves in Schedule 10 pipe shall be rolled groove only. Pipe having wall thicknesses less than Schedule 10 are unacceptable.

B. Piping Sizes 2 inches (50 mm) and Smaller

1. Steel Pipe: Steel piping shall be ASTM A-53/A-135/A-795, Weight Class STD (Standard), Schedule 40, Type E or Type S, Grade A, steel pipe with threaded end connections. Fittings shall be ASME B16.39, Class 150, cast or ductile iron threaded fittings. Unions shall be ASME B16.39, Class 150, unions. Pipe may also be joined using grooved couplings and fittings. Where grooved joining is used, cut or rolled grooves are acceptable.
2. Post-chlorinated Poly Vinyl Chloride (CPVC) shall not be acceptable.

C. Pipe Hangers and Supports

1. Pipe hangers and supports shall be UL listed, FM approved, and California State Fire Marshal approved, and shall be the adjustable type. Installation shall be according to the manufacturers' listing.
2. Seismic hangers and bracing shall be UL listed, FM approved, and California State Fire Marshal approved for fire protection use and shall be installed in accordance with their listings and manufacturers' recommendations. Type, quantity, and spacing shall be in accordance with the requirements for the specific seismic zone requirements and those of NFPA.

2.4 CONTROL AND DRAIN VALVES

A. Sprinkler system control and drain valves shall be the following types:

1. O.S&Y. gate valves.
2. Post indicator valves shall be direct buried, made of cast iron body, resilient wedge construction, fusion epoxy lined and coated, non-rising stem with cast iron body, adjustable type and conforming to AWWA specifications. Post indicator shall be cast iron body, adjustable type and include non-breakable plastic windows to indicate the valve position. Post indicator valves shall have operating wrench attached to the post indicator. Valves are to be locked in the open position.
3. Butterfly valves with gear operator assembly and open/closed position indicator. Butterfly valves shall have an integrated, factory-installed supervisory (tamper) switch.
4. Brass seated, straight-way or angle globe valves for main drain and inspector's test. System Gauges shall be riser mounted to ¼ inch, three-way globe valves.
5. Riser check valve: A riser check valve shall be provided on the building water supply riser, prior to the fire department connection. The riser check valve shall have a cast iron body and shall be of the "swing check" type/style. Wafer type check valves will not be permitted.

B. All valves must be UL listed, FM approved, California State Fire Marshal approved for their intended use.

C. Signs: All water supply control valves and drain valves shall be marked with metal signs and shall be secured with metal chains or other means approved by Owner and AHJ to show their function and sprinkler system zone which they serve. Attachment of signs to the valves with adhesives is not permitted.

D. Pressure Ratings: Pressure ratings of all valves shall meet or exceed maximum working pressures available within the system.

E. Supervision: All system control valves shall be capable of being locked in the open position. System control valves shall be equipped with electronic supervisory (tamper) switch having two normally open contacts (rated for 24vdc service). and shall be electrically supervised by the building fire alarm system.

F. Access Panels: Furnish and install access panels (minimum size 12-inches by 12-inches) for all control valves located above finished ceilings or concealed in walls. Owner will select finish of access panels. Access panels installed in fire resistive construction shall be of the types required for maintaining proper protection of assembly.

G. Valves and assemblies that are exposed to potential damage by vehicles or other traffic are to be protected by providing a cage or other approved barrier when located inside the building.

2.5 ELECTRICAL WORK

A. Furnish all labor, equipment and services necessary for the design and installation of required connections as required to complete fully operational system(s). Contractor will be responsible for the mounting of all water flow, tamper, and pressure switches for the fire protection systems in this Section. Wiring of such devices is outside the scope of this specification. Wiring of such devices is included in the Alarm and Detection specification and is the responsibility of the A&D contractor.

B. Service. Confirm power connections with electrical contractor.

C. Testing. Provide the required assistance to the Alarm and Detection Contractor to test, adjust and place the fire protection system(s) into initial operation.

2.6 SPRINKLERS

A. Contractor shall furnish and install fire sprinklers of the following types and finishes:
   1. Semi-recessed Quick-Response (QR) pendent sprinklers shall be installed in all areas with ceiling. Recessed sprinklers shall be a UL listed or FM approved assembly, and the escutcheon shall be integral to the sprinkler. Finish shall be white escutcheon with white polyester sprinkler unless otherwise directed by the Owner/Architect in the submittal process.
   2. Standard upright or pendent sprinklers shall be installed in non-public, unfinished areas. Sprinkler finish shall be white polyester, unless otherwise directed by the Owner/Architect in the submittal process.
   3. Standard temperature upright, or pendent with cage guards, shall be installed in areas subject to damage (e.g., under stairs and mechanical rooms). Fusible link style sprinklers shall be acceptable in areas subject to damage. Sprinkler finish in such areas shall be brass, unless otherwise directed by the Owner/Architect in the submittal process.

B. Final Selection: Owner will select finishes for all automatic sprinklers and escutcheons.

C. Uniformity: All sprinklers within a space shall be from the same manufacturer and shall have the same type and style of heat response element, including temperature rating and response characteristics.

D. Temperature Rating: It shall be Contractor's responsibility to install sprinklers of the proper temperature rating as required by NFPA 13.

E. Corrosion Resistance: Sprinklers located on exterior piping systems or in areas exposed to corrosive atmospheres shall be UL listed and/or FM approved corrosion resistant coated or stainless steel.

F. Sprinkler Escutcheons: Flush sprinkler escutcheons shall be metal and shall be listed for use with the sprinklers. Recessed sprinklers and escutcheons shall be UL listed and/or FM approved as an assembly, and the sprinkler and escutcheon shall be of the same manufacturer.

G. Sprinkler Orifice: Sprinkler orifice sizes shall be confirmed through hydraulic calculations for the system(s). Sprinklers having a nominal ‘K’ factor of less than 5.6 are not acceptable unless specifically allowed by NFPA 13. The orifice size shall be uniform within a protected area.

H. All sprinklers in finished areas shall be center of tile plus or minus 2 inches, unless approved by the Owner. All sprinklers shall be aligned in all directions when multiple sprinklers are in the same area and are in the same line of sight. Contractor shall coordinate location of all sprinklers in finished areas with architect and Owner.

I. Where acceptable to AHJ, the use of flexible drops is **preferred and requested** by the Owner and Architect, but all such drops must be installed in accordance with their UL listings and/or FM approvals. Where such listings/approvals differ, the most stringent installation requirements will apply. The use of flexible drops shall be accounted for in all hydraulic calculations for the system(s). Flexible drops shall be of the braided, stainless steel hose style. Flexible drops employing corrugated steel tubing will not be permitted.

2.7 IDENTIFICATION SIGNS

A. Contractor shall furnish and install hydraulic calculation signs for each new sprinkler zone. Hydraulic calculation signs shall be affixed to the corresponding system riser downstream of the system control valve and main drain at the riser. Contractor shall also provide identification signs for all valves installed under this section.

B. Hydraulic calculation signs shall include all information indicated in NFPA 13 and its appendices. Valve identification signs shall identify the function of the valve and the area served.

C. Conspicuous identification signs shall be provided at each standpipe hose connection as required by NFPA 14.

D. Identification signs shall be rigid, metal plaques with embossed enamel background and lettering. Signs shall be secured by chain or durable wire to each sprinkler zone control valve, main and auxiliary drain, and inspector’s test valve. System hydraulic calculation placards affixed using adhesives, and/or using permanent marker for information, are NOT acceptable.

2.8 FIRE DEPARTMENT CONNECTION, STANDPIPE AND HOSE EQUIPMENT

A. Standpipe Hose Valves: Standpipe hose valves shall be suitable for Class I standpipe service as defined by NFPA 14. Standpipes shall be equipped with a 2-1/2 inch brass hose valve(s) at the floor level of each stairwell and on the roof level. The 2-1/2 inch hose valve(s) shall be brass bodied, angle style, and shall be female inlet x male hose thread outlet. The 2-1/2 inch inlet threats shall be NPT, and the male hose threads shall match the requirements of the local fire department. Hose valves shall be mounted approximately 48 inches above each stairwell floor level. Valve bodies shall be cast brass, and shall be rated for 300 psi service. The finish of the valves shall be brass or polished chrome and approved by the local fire department and the Owner. All standpipe hose valves shall be UL listed and/or FM approved for their intended service, and valves shall be of a single manufacturer. The valves and hose threads shall be acceptable to the local AHJ. The standpipe hose valve shall be Zurn/Wilkins Model Z3000 or equivalent of the same size and dimensions. Hose connections to be provided within enclosure/cabinet where indicated by Architect and/or Owner.

B. Hose Cabinets and equipment: The contractor shall coordinate the location and size of any and all equipment selected with the Owner prior to installation. Hose cabinets shall be conspicuously identified as required by NFPA 14.

2.9 SUPERVISORY AND ALARM EQUIPMENT

A. All waterflow and valve supervisory switches shall be furnished, installed and properly adjusted by the sprinkler contractor. Alarm monitoring of these devices will be by others.

B. Contacts: All waterflow and valve supervisory switches shall be provided with two "Form C" (D.P.D.T.) contacts for monitoring. Specific contact rating shall be coordinated with the fire alarm contractor.

C. Waterflow Switches: Vane-type and/or pressure-type water flow indicators shall be provided to indicate waterflow in each sprinkler system zone and shall by UL listed and/or FM approved. All water flow switches shall be equipped with an adjustable retard setting that can be varied from 0 to 60 (minimum) seconds.

D. Supervisory Switches: Valve supervisory (tamper) switches shall be provided for all valves controlling the water supply to the sprinkler systems. Valve supervisory switches for OS&Y type valves shall be the yoke mounted or integral type. Supervisory switches for butterfly style valves shall be factory installed and integral to the valve assembly.

E. Loop Type Valve Supervisory Switches: Contractor shall not use wire loop type switches.

2.10 INSPECTOR'S TEST AND DRAIN ASSEMBLY(S)

A. For multiple level installations, an inspector's test and drain assembly(s) shall be provided at each floor connection to a riser for the wet-pipe system(s). This test and drain assembly may be a modular unit type.

B. For applications other than that specified in 2.11A, an inspector's test and drain assembly shall be provided at the most hydraulically remote part of the wet-pipe system and shall discharge to a location approved by the Owner. The inspector's test piping arrangement for wet system(s) shall be in compliance with the requirements of NFPA 13.

C. Inspector's test and drain assemblies shall comply with the requirements of NFPA 13. All components of test and drain assemblies shall be UL listed and/or FM approved.

2.11 STANDPIPE DRAIN RISER

A. Three (3) inch drain risers shall be provided adjacent to each standpipe as required by NFPA 14 to facilitate testing of the pressure regulating hose valves. The drain risers shall be provided with a 3-inch by 2½-inch tee with a plug and shall be located on at least every other floor. Location of the drain plugs and drain discharge shall be approved by the Owner.

2.12 MISCELLANEOUS PRODUCTS

A. Pressure Gauges: Pressure gauges shall be UL listed 3-1/2-inch minimum diameter, dial type gauges with a maximum limit of not less than twice the normal working pressure at the point installed. All gauges shall be provided with ¼ inch, 3-way shut-off valve (gauge-cock).

PART 3 - EXECUTION

3.1 WORKING CONDITIONS

A. Contractor shall visit the site and become familiar with the conditions under which the work will be performed.

B. Contractor's installation shall be performed in accordance with the project's master specification and/or Owner direction. Contractor will have site access during working hours.

3.2 PREPARATION FOR WORK

A. Cooperation with other trades: Contractor shall coordinate with the work of the other trades towards the general purpose of having the construction progress as rapidly and as smoothly as possible with a minimum of interference between trades.

B. Before the start of Structural Work, Contractor shall submit to Owner locations, sizes, and instructions for openings and penetrations required for his work. Submittal and proposed penetrations shall be subject to Owner's approval. Contractor shall provide any additional penetrations or openings or relocation required, that were not addressed in their initial submittal at no additional cost to Owner.

C. Approval prior to installation: No work shall commence prior to approval of shop drawings by the approving authorities, including Owner. Any change in work that has been installed prior to approval of the shop drawings shall be made without additional compensation to Contractor.

3.3 GENERAL INSTALLATION

A. Aesthetics shall be a primary consideration when installing sprinklers and sprinkler piping in all areas. Any facet of sprinkler installation that deviates from the approved shop drawings and does not meet with Owner's approval shall be revised by Contractor to Owner's satisfaction at no additional cost.

B. All holes made by Contractor in any wall, ceiling, or floor shall be patched by Contractor, restoring the wall, ceiling, floor or member to its intended condition, fire resistance, and integrity.

C. Location of all equipment, controls, piping, valves and drains shall be subject to Owner's approval.

D. All sprinklers and equipment shall be installed in accordance with manufacturers' instructions. All special tools, including sprinkler wrenches, recommended by the manufacturer shall be used.

E. Sprinklers shall be installed with the deflector to ceiling distances in accordance with their UL listings and/or FM approval and the requirements of NFPA 13.

3.4 PIPING

A. All sprinkler piping installed in public areas or non-public areas with suspended ceilings shall be concealed in the walls, ceilings or soffits. Pipe in unfinished areas may be exposed.

B. All piping exposed within the building public areas shall be painted with one coat by Contractor. Owner is to select the colors. All exterior piping shall be primed with zinc chromate and painted by Contractor.

C. Escutcheon Plates: All exposed pipe which passes through a wall, ceiling, or floor shall be provided with metal escutcheon plates.

D. Minimum Height: All exposed piping and devices shall be installed as high as possible, but no less than seven (7) feet clear above the finished floor in traffic or working areas, so as not to obstruct any portion of a window, doorway, stairway or passageway. Pipe and fittings shall not interfere with the operation or accessibility of any mechanical, plumbing or electrical equipment.

E. Operating Chains: Valves controlling water supply to the sprinkler systems shall be less than seven (7) feet above the finished floor. When specifically approved by Owner, they may be higher and must be provided with operating chains.

F. Protection: Contractor shall provide Owner approved, adequate permanent protection for any installed piping, valves, devices or accessories which, in Owner's opinion, are subject to physical damage or may be hazards.

G. Firestopping: Pipe that passes through fire-rated resistive barriers (including shaft walls) shall be sleeved and grouted or sealed with a UL-listed through-penetration fire stop system to maintain the integrity and rating of the fire resistive barrier.

H. Testing: All piping is to be flushed and hydraulically tested prior to acceptance by owner. Flushing and testing must be performed in accordance with NFPA standards.

I. Contractor shall provide all equipment necessary for testing and flushing and any special equipment required for the installation of any portion sprinkler (and/or standpipe) system(s). Contractor shall remove all such equipment at the end of the job.

J. All above ground piping 2-1/2" and larger shall be provided with labels at 20-foot intervals indicating sprinkler system piping.

3.5 SYSTEM TEST AND DRAIN CONNECTIONS

A. Contractor shall provide all test valves and drain connections as required by NFPA 13.

B. All test connections and drain riser connections shall be hard piped to discharge waste water to the floor drain within the Fire Riser Room, or as required by the AHJ. When acceptable to Owner, drain piping may terminate at an interior drain of sufficient size and capacity to accommodate the anticipated maximum flow. The sprinkler contractor shall coordinate routing of the drain pipe and points of discharge.

3.6 STANDPIPE DRAIN RISER CONNECTIONS

A. Contractor shall provide all standpipe drain riser connections as required by NFPA 14.

B. All drain riser connections shall be hard piped to discharge waste water to the floor drain within the Fire Riser Room, or as required by the AHJ. When acceptable to Owner, drain piping may terminate at an interior drain of sufficient size and capacity to accommodate the anticipated maximum flow. The sprinkler contractor shall coordinate routing of the drain pipe and points of discharge.

3.7 RISERS

A. Contractor shall locate the main risers for the sprinkler system to minimize obstruction to traffic or building operations. Exact location of risers shall be approved by Owner.

B. Zoning: The fire sprinkler system shall be zoned on a per floor basis and divided into zones as noted herein (and/or on the riser diagram shown on the contract drawings). Sprinkler zones shall not exceed the maximum area per zone specified in NFPA 13. Sprinkler zoning (and alarms) will also conform to alarm and detection and smoke control system zoning.

C. Supervisory Switches: Valve supervisory switches shall be provided on all valves controlling water supply to the fire sprinkler system, including valves located at backflow preventers.

3.8 FLUSHING AND SANITIZATION

A. All equipment and materials prior to installation shall be clean inside and outside. All waste material such as chips, filings, welding stubs, dirt, rags, debris, and any other foreign material shall be removed from the components before assembly.

B. All steel pipe coupons or punched holes for welded or mechanical outlets shall be attached to the pipe near the pipe hole. Protective plastic caps shall be located over openings and pipe ends during installation to prevent foreign material from entering the pipe at any time.

3.9 SEISMIC CONSIDERATIONS

A. Sprinkler piping on any floor level may cross building structural separations such as expansion and seismic joints, provided that the piping is specifically designed with flexible connections at each crossing and able to accommodate the calculated differential motions during an earthquake, but not less than a minimum of 24 inches. All required structural, differential movement and drift calculations shall be prepared by a licensed structural engineer possessing current California registration. (Contractor shall verify locations of seismic joints.)

3.10 SWAY BRACING, FLEXIBLE COUPLINGS, HANGERS

A. All flexible couplings, hangers and sway bracing shall be designed and installed as required by NFPA 13 (including all appendices) and in accordance with their listings and/or approvals. Flexibility, internal pressure, and differential movement between the piping and building, earth, or other supporting structure(s) shall be allowed for, so that no allowable stress is exceeded in any member.

3.11 TRAINING

A. Contractor shall conduct two (2) training sessions of four (4) hours each at the project site to familiarize the building personnel with the features, operation and maintenance of the sprinklers. Training sessions shall be scheduled by Owner at a time mutually agreeable to Contractor and Owner.

B. Agenda: Contractor shall submit a proposed training agenda for Owner's review and approval within 60 days of receipt of authorization to proceed. The proposed training agenda shall include, but not be limited to, the following:

1. Overview of system operation.
2. Overview of system equipment and device locations.
3. Detailed operation guidelines.
4. Detailed maintenance procedures.
5. Periodic testing procedures.

C. Final Agenda: Contractor shall submit the final approved training agenda 14 days prior to the first training session.

3.12 FINAL INSPECTION AND TEST

A. Contractor shall make arrangements with Owner for Owner's final inspection and witnessing of the final acceptance tests. This test shall be separate from testing by the local authorities.

B. All tests and inspections required by the referenced Codes and Standards, AHJ, and Owner shall be conducted by Contractor under this scope of work.

1. When AHJ are required to witness tests, Contractor shall be responsible for making all necessary arrangements with the code authorities and coordinating the testing with Owner.
2. Contractor shall be responsible for completing all test documents with necessary approval stamps and signatures of the AHJ. Contractor shall submit one copy of each of these documents to Owner for their records.

C. Acceptance Testing: Upon completion of each system, perform and document on an NFPA or approved format, system tests as described herein. All acceptance tests shall be performed in the presence of Owner.

1. Hydrostatic tests.
2. Flushing of piping.
3. Test of sprinkler supervisory system – The Alarm and Detection Contractor should be present at the testing of all sprinkler alarm and supervisory devices. This Contractor shall coordinate the final testing of all such devices with the Alarm and Detection Contractor.
4. Contractor to provide NFPA testing certificate to the Owner, the local fire authority, the project architect, and DSA.

D. Contractor shall provide at least five (5) working days' notice for all tests to all involved.

3.13 FINAL APPROVAL

A. Final approval and acceptance of the work will be given by Owner when:

1. The completed sprinkler system(s) has (have) been inspected, tested and approved by Owner and AHJ.
2. Required submittals, system operation and maintenance manuals, record drawings, spare parts, special tools and training have been provided to, reviewed, and accepted by Owner.
3. Written certification is submitted that states all equipment has been inspected and tested by a manufacturer's certified representative.
4. Written certification is submitted that states all equipment is installed in accordance with the manufacturer's recommendations and UL and/or FM approvals.

B. Owner's Representative may visit the job site to observe the work and witness the final acceptance tests when advised by Contractor that the work is complete and ready for test. If the work has not been completed, or the test is unsatisfactory, Contractor shall be responsible for Owner's added expenses for re-inspection and witnessing the retesting of the work. Such extra fees shall be deducted from payments by Owner to Contractor.

C. Additional Tests: Any additional tests, required by the referenced codes, standards, or criteria, or by Owner, shall be performed. This documentation shall include:

1. The date and time of each test.
2. A reference set of contractor record drawings, numerically identifying the individual components

and circuits tested, and test locations.
3. A description of each test performed.
4. A checklist of each device tested, indicating the results of each test.
5. The names and signatures of the individuals conducting and witnessing each test.

3.14 FIELD QUALITY CONTROL

A. Scheduling of Work

1. Coordinate the installation schedule for this portion of the work with the overall construction schedule for the project to ensure orderly progress of the work without delay.
2. Coordinate the interface of the automatic sprinkler system with the work of all other trades as well as new construction to ensure proper and adequate provision for the installation and connection of this system.

3.15 HOUSEKEEPING

1. Upon completion of the work the Contractor will completely remove all debris and excess materials from the job site.

3.16 GUARANTEE PERIOD

A. Except as otherwise expressly provided in the Contract Documents, and excepting only items of routine maintenance, ordinary wear and tear or unusual abuse or neglect, Contractor guarantees all work executed by Contractor and all supplies, materials and devices of whatsoever nature incorporated in, or attached with the work, or otherwise delivered to the Owner as part of the work pursuant to the contract to be absolutely free of all defects of workmanship and materials for a period of one year after final acceptance of the work by Owner’s Representative.

1. Include service directory with telephone numbers for 24-hour emergency service.

END OF SECTION

SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of this Section shall apply to the entire Division 22 work, and Section 23 1123 – FACILITY NATURAL GAS PIPING.

B. All referenced and related provisions of Divisions 21, 23 and Division 26 shall also apply to the work of this Section as if fully repeated herein.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

D. Refer to General Commissioning Requirements on Section 019113.

1.2 WORK OF THIS SECTION

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Plumbing demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, 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 chases.

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. PE: Polyethylene plastic.
2. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-dieneterpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of plumbing fixtures of type, style, and configuration required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Regulatory Requirements

1. PDI Compliance: Comply with standards established by PDI pertaining to plumbing fixture supports.
2. UL Compliance: Construct water coolers in accordance with UL 399, and furnish UL listing and label.
3. ASHRAE Compliance: Test and rate water coolers in accordance with ASHRAE 18.
4. ANSI Standards: Comply with applicable ANSI barrier-free plumbing fixture standards.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery plumbing fixtures individually wrapped in factory-fabricated containers.

B. Handle plumbing fixtures carefully to prevent breakage, chipping, and scoring fixture finish. Do not install damaged plumbing fixtures; replace damaged units

C. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION WITHIN DIVISION 22

A. Contract Documents

1. General: The contract documents are diagrammatic showing certain physical relationships, which must be established within Division 22 work and its interface with other work. Such establishment is the exclusive responsibility of the Contractor.
2. Drawings shall not be scaled for the purpose of establishing dimensions, clearances or material quantities.
3. Supplemental Instructions: The exact location for some items in this specification may not be shown on the Drawings. The location of such items may be established by the Owner Representative during the progress of the work.
4. Discrepancies
   a. Examine drawings and specifications of all Divisions of the work.
   b. Report any discrepancies to the Owner’s Representative and obtain written instructions before proceeding.

B. Contractor shall be responsible to furnish proper documentation of equipment product data and shop drawings to all entities providing services.

C. Coordination Drawings: Prepare coordination drawings in accordance with Section 01 3323 – SHOP DRAWINGS, PRODUCT DATA & SAMPLES to scale of 1/8” = 1”-0” or larger for floor plans, and 1/4” = 1’-0” for equipment rooms and restrooms, detailing major elements, components, and systems mechanical equipment (i.e. equipment rooms, and exterior equipment areas) and materials in relationship with other system, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to the efficient flow of the work, including (but not necessarily limited to) the following:

1. Indicate all major piping (HVAC, Plumbing and Fire Protection), electrical equipment and conduits, structural, and architectural elements in the areas as well.
2. Sizes and locations of required concrete pads, piers, curbs and bases.
3. Furnish all necessary sections and elements for clarification.

4. Indicate all seismic restraint and support systems to be used for all plumbing equipment throughout the project.
5. Ductwork and piping transitions from rooftop units to shafts or horizontal ducts.
6. Failure to produce or submit coordination drawings does not dismiss the Contractor's responsibility for translating the design intent of the contract documents into construction drawings.

D. Utility Connections
   1. Coordinate the connection of plumbing systems with utilities and services.
   2. Comply with regulations of utility suppliers.
   3. The contract documents indicate the available information on existing utilities and services, and on new services (if any) to be provided to the project by utility companies and agencies.
      a. Notify the Owner's Representative immediately if discrepancies are found.
   4. Refer to Section 01 1400, WORK RESTRICTIONS, for utility shut-down requirements.

E. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

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

G. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 3113 – ACCESS PANELS AND FRAMES.

1.7 COORDINATION WITH OTHER DIVISIONS

A. General
   1. Coordinate the Division 22 work.
   2. Contractor is responsible for coordination of his / her work with building automation, commissioning of systems, fire alarm system, etc.

B. Coordination with Electrical work: Refer to Section 26 0500 – COMMON WORK RESULTS FOR ELECTRICAl.

C. Cutting and patching: Refer to Section 01 7329 – CUTTING AND PATCHING for general demolition requirements and procedures.

D. Support Dimensions: Furnish dimensions and drawings so that concrete bases and other equipment supports to be provided under other sections of the specifications can be built at the proper time.

1.8 ENGINEERING BY CONTRACTOR

A. The construction of this building requires the Contractor to design several systems or sub systems. All such designs shall the complete responsibility of the Contractor.

B. Systems or sub-systems which require responsibility by the Contractor and submitted to the Owner's Representative for review include, but are not limited to:
   1. Equipment and piping supports.
   2. Pipe hangers and anchors not specified in these documents, or cataloged by the manufacturer.
   3. Vibration Isolation / Seismic Restraint.
   4. Underground piping distribution systems.
   5. Thermal pipe stress analysis

1.9 REGULATORY REQUIREMENTS

A. Refer to Section 01 4100, REGULATORY REQUIREMENTS.

B. Additional Regulations: Follow additional regulations which appear in individual sections of these specifications.

C. Inspections and Tests
   1. Arrange for all required inspections and tests.

2. Notify the Owner’s Representative in writing 72 hours before tests.
3. Submit three copies for Owner’s Representative record licenses, inspection reports and test reports.

1.10 SUBSTITUTIONS

A. Refer to Section 01 2513, PRODUCT SUBSTITUTION PROCEDURES.

1.11 GENERAL SUBMITTAL REQUIREMENTS

A. Refer to Division 01.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

C. Submittals: Contractor shall submit proof of qualifications.

D. Coordination and Sequencing
   1. Plumbing products requiring approval by the State of California Dept. of Industry, Labor and Human Relations must be approved or have pending approval at the time of shop drawing submission.
   2. Welding certificates and requirements.
   3. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
   4. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   5. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   6. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
   7. Coordinate submittals 3 weeks (minimum) prior to expected order date so that work will not be delayed by submittals.
   8. Do not submit product data, or allow its use on the project until compliance, with requirements of Contracted Documents has been confirmed by Contractor.
   9. Submittal is for information and record, unless otherwise indicated, and is not a change order request.
   10. Make submittals for group of similar products or materials such as valves, fixtures, pumps, insulation, etc., or area or work complete and at one time, not in piecemeal fashion.

E. Preparations of Submittals
   1. Refer to Division 01 requirements.
   2. Furnish permanent marking on each submittal to identify project, date, Contractor, SubContractor, Supplier, submittal name and similar information to distinguish it from other submittals.
   3. Show Contractor’s executed review and approval markings.

F. Quantities: Unless otherwise indicated in Division 01, submit six copies.
   1. Refer to Division 01 requirements.
   2. Multiple Systems Items: Where a required submittal relates to an operational item of equipment used in more than one system, increase the number of final copies as necessary to complete the Maintenance Manuals for each system.
   3. General Distribution:
      a. Furnish additional distribution of submittals (not included in Division 1) to SubContractors, suppliers, fabricators, installers, governing authorities and others as necessary for proper performance of the work.
      b. Include such additional copies in transmittal to Owner’s Representative where required to receive “Action” marking before final distribution.
      c. Show such distributions on transmittal forms.

G. Record Drawings ("as-builts") are extremely important to the ongoing operation of the facility, but are often neglected in the crisis of construction. The engineer and inspector should verify at each site visit that the contractor is maintaining adequate as-builts, and should obtain progress copies of the contractor's as-builts during construction. At the completion of the project, it is too late to verify concealed work and documents are often misplaced.

1.12 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS

A. Manufacturer's Data
   1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black ink to indicate which of the variations is to be furnished.
   2. Delete or mark out significant portions of pre-printed data, which are not applicable.
   3. Where operating ranges are shown, mark data to show portion of range required for project application.
   4. For each product, include the following:
      a. Sizes.
      b. Dimensions.
      c. Weights.
      d. Speeds.
      e. Capacities.
      f. Fixture Color.
      g. Cabinet Finish.
      h. Piping and Electrical connection sizes and locations.
      i. Statements of compliance with the required standards and regulations.
      j. Performance data.
      k. Manufacturer's specifications and installation instructions.

B. Shop Drawings: Prepare Plumbing Shop Drawings, except diagrams, to accurate scale.
   1. Show clearance dimensions at critical locations.
   2. Show dimensions of spaces required for operation and maintenance.
   3. Show interfaces with other work including structural support.

C. Test Reports
   1. Submit test reports, which have been signed and dated by the firm performing the test.
   2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.

D. Required Equipment and Shop Drawing Submittals
   1. Furnish equipment submittals for each item of equipment specified of scheduled in the Contract Documents.
   2. Submittal schedule shall show each item of equipment, applicable section of the specifications where it is described, applicable drawing number and schedule name where it is scheduled, date of Contractors proposed submittal to the Owner's Representative and schedule order date.
   3. Furnish a plumbing shop drawing schedule for submission to the Owner's Representative with the submittal schedule.

1.13 CAPABILITY

A. General: Provide products, which are compatible with other products of the plumbing work, and with other work, requiring interface with the plumbing work.

B. Power Characteristics: Where power requirements are not stated in Division 22 Sections, refer to Sections of Division 26 and the electrical drawings for the power characteristics of each power driven item of plumbing equipment. Coordinate available power with Division 23 before ordering equipment. Order equipment to meet the available power characteristics. If there is a conflict between Division 22 documents and Division 26 documents, furnish a written notification to the Owner's Representative for direction. Do not order equipment prior to determining the proper electrical service. No contract cost adjustment will be allowed for equipment ordered in conflict with the available power characteristics.

1.14 AS-BUILT DRAWINGS

A. Drawings

1. Refer to Section 01 78 39, Project Record Documents.
2. Include in Record Drawings the Following
   a. Revisions, including sketches, bulletins, change orders, written addenda and directives, clarifications and responses generated by requests for information (RFI's), regardless of source of the revision.
   b. Location and configuration of equipment with related housekeeping pads.
   c. Location of fixtures, drains and appurtenances.
   d. Physical routing of piping, underground, exposed, and above ceiling with locations of valves and accessories plainly marked and identified.
   e. Location of piping below building and exterior, valves, manholes, appurtenances and stub outs dimensioned from buildings and permanent structures, both horizontally and vertically.
   f. Location of wall and ceiling access panels.

1.15 OPERATION AND MAINTENACE DATA

A. Refer to General Conditions.

B. Submission

1. Submit three typed and bound copies or Operating and Maintenance (O&M) Manuals for each type of fixture and piece of equipment prior to scheduling systems demonstrations for the Owner's Representative.
2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings.
3. Mark the spine of each binder with system identification and volume number.

C. Required Contents

1. Manuals shall have index with tab dividers for each major equipment section to facilitate locating information on a specific piece of equipment.
2. Identify data within each section with drawing code numbers as they appear on drawings and specifications. Include as a minimum the following data:
   a. Alphabetical list of system components, with the name, address and 24-hour telephone number of the company responsible for servicing each item during the first year or operation. Include point of contact for company.
   b. Operating instructions for complete system including:
      1) Emergency procedures for fire and failure of major equipment.
      2) Major start, operation and shut down procedures.
   c. Maintenance instructions for each piece of equipment including:
      1) Equipment lists.
      2) Proper lubricants and lubricating instructions for each piece of equipment.
      3) Necessary cleaning, replacement and/or adjustment schedule.
      4) Product data.
      5) Installation instructions.
      6) Parts list.
   d. Marked or changed prints locating concealed parts and variations from the original system design (As-built drawings).
   e. Valve schedule and associated piping schematics, see Section 22 0553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT.
   f. Copies of any extended equipment warranties which are greater than one year.

1.16 WARRANTIES

A. The warranty period shall be no less than two (2) full years, unless specified otherwise hereinafter .

B. During the warranty period, the contractor shall guarantee the following in a form satisfactory to the Owner:

1. All Work installed will be free from any and all defects in Workmanship and/or materials.
2. All equipment, apparatus will develop capacities and performance characteristics specified .
3. The systems shall operate without malfunction .

C. The contractor shall, without cost to the Owner, remedy any defects within a reasonable time to be specified in notice from the Architect. In default thereof, the Owner may have such Work done and charge all costs to the Subcontractor.

D. The start of the contractor's warranty period, as defined in the General Conditions, shall commence on the issue of a "Certificate of Substantial Completion", by the Owner or the Owner's Representative for each item of material, equipment or system.

E. The contractor shall confer prior to the bid date concerning the Schedule and determine if there is a need to operate any items of equipment or systems for temporary heating and/or cooling or other reasons prior to substantial completion. All required extended warranty costs for equipment, materials and systems shall be included in the contractor's proposal.

1.17 SPARE PARTS, SPECIAL TOOLS

A. Deliver spare parts to the Owner's Representative and obtain receipts at the time operating instructions are given to Owner's Representative personnel.

B. Include the following:

1. V-belts: One complete set of each size.
2. Fuses: Each type used for all equipment utilizing fuses. Quantity 10 percent, but not less than two.
3. Pilot light lamps: each type used on the project. Quantity 10 percent, but not less than two.
4. Special Tools: Furnish special tools required for assembly, adjustment, setting or maintenance of equipment if such tool is not readily available on the commercial tool market.
5. Maintenance Paint: Furnish one can of touch up paint for each different factory finish, which is to be the final finished surface of the product.

1.18 SYSTEM ACCEPTANCE

A. Acceptance shall be contingent upon completion of final review and correction of all deficiencies. Satisfactory completion of the operational tests, which shall demonstrate compliance with all performance criteria, and the requirements of the contract documents.

B. Request a final review prior to system acceptance after completion of the following:

1. Installation of all systems required by contract documents.
2. Submission and acceptance service manuals.
3. Identification.
4. Cleaning.
5. Satisfactory operation of all systems for a period of one week.

1.19 OWNER FURNISHED / CONTRACTOR INSTALLED EQUPMENT

A. All equipment called out in the specifications or shown on the drawings as "Owner Furnished/ Contractor Installed" shall be installed and connected under this contract. Provide rough-ins for all future connections indicated unless otherwise specifically indicated on drawings.

1.20 TEMPORARY FACILITIES

A. Light, heat, power, etc.

1. Contractor shall be responsible for providing temporary electricity, heat and other facilities as specified in Division 01.

1.21 SAFETY PROVISIONS

A. Equipment Nameplates: Provide power oriented plumbing equipment with a permanent nameplate attached by the manufacturer, indicating:

1. The manufacturer.
2. Product name.
3. Model number.
4. Serial number.
5. Speed.

6. Capacity.
7. Power characteristics.
8. Labels of testing, or inspecting agencies.
9. Other similar data.

B. Where manufacturer affixed nameplate is not available, Contractor shall fabricate and attach nameplate.

C. Guards
   1. Unless equivalent guards are provided integral with the equipment, enclose each belt drive (including sheaves) on both sides in a galvanized, one inch, mesh screen of No. 18 gage steel wire or expanded metal, fastened to an approved, structure steel frame, securely fastened to the equipment or floor.
   2. Provide tachometer holes at shaft centers. Unless equivalent guards are provided integral with the equipment, install a solid guard of No. 20 gage galvanized steel over the coupling of each item of direct driven equipment.
   3. Sides are not required on these guards except to ensure rigidity.

1.22 LEAD FREE PRODUCTS FOR INSTALLATION

A. On January 1, 2010 Assembly Bill AB-1953 became law which calls for the installation of lead free products in plumbing systems.

B. The Contractor shall install products that comply with the requirements as described in State Assembly Bill AB-1953.

C. Submit all lead free products to be installed to the Owner's Representative for review.

1.23 TRAINING OF OWNER'S PERSONNEL

A. Confirm training requirements listed below with the Owner.

B. Furnish the Owner's designated personnel with five 8-hour days of training and instruction. The training and instruction sessions shall be conducted at the Owner's convenience.

C. All training of personnel shall be completed before final inspection.

D. All training shall be conducted within the project boundaries. If this is not possible, all the costs associated with travel, room and board of the Owner's Personnel selected to attend the training session shall be at no additional cost to the Owner.

E. All training shall be videotaped and submitted to Owner for their record.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. If no manufacturer is listed, "Basis of Design" is industry standard indicated.

B. Provide all plumbing fixtures complete with all necessary trim and accessories to insure the specified complete installation and operation of each fixture. Include trim and accessories, not to be limited to, rigid brass, supply pipes, stops, drains, strainers, tailpieces, P-traps, escutcheon plates and bolt caps.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping
   1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers
      a. Cascade Waterworks Mfg. Co.
      b. Dresser Industries, Inc.; DMD Div.
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
      d. JCM Industries.
      e. Smith-Blair, Inc.
      f. Viking Johnson.
      g. Or equal
   2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
   3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
   4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Manufacturers
      a. Eslon Thermoplastics.
      b. Or equal.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Manufacturers
      a. Thompson Plastics, Inc.
      b. Or equal.

D. Plastic-to-Metal Transition Unions: MSS SP-107, PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
   1. Manufacturers
      a. NIBCO, Inc.; Chemtrol Div.
      b. Or equal.

E. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C 1173 with elastomeric sleeve ends same size as piping to be joined, and corrosion-resistant metal band on each end.
  1. Manufacturers
    a. Cascade Waterworks Mfg. Co.
    b. Fernco, Inc.
    c. Mission Rubber Company.
    d. Plastic Oddities, Inc.
    e. Or equal.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

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

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig minimum working pressure as required to suit system pressures.
  1. Manufacturers
    a. Epco Sales, Inc.
    b. Watts Industries, Inc.; Water Products Div.
    c. Zurn Industries, Inc.; Wilkins Div.
    d. Or equal.

D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
  1. Manufacturers
    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.
    e. Or equal.
  2. Separate companion flanges and steel bolts and nuts shall have 150 or 300 psig minimum working pressure where required to suit system pressures.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  1. Manufacturers
    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Metraflex Co.
    d. Pipeline Seal and Insulator, Inc.
    e. Or equal.
  2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  3. Pressure Plates: Carbon steel. Include two for each sealing element.
  4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

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

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Under deck Clamp: Clamping ring with set screws.
   2. Manufacturers
      a. Zurn Industries.
      b. JR Smith.
      c. Or equal.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw and polished chrome-plated finish.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw and polished chrome-plated finish.

E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

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

2.10 WALL PENETRATION SYSTEMS

A. Manufacturers:
   1. SIGMA.
   2. ProSet.
   3. Or equal.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.
   1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
   2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
   3. Housing-to-Sleeve Gasket: EPDM rubber.
   4. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber.
   5. Pipe Sleeve: AWWA C151, ductile-iron pipe or ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in work of potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.

B. Examine floors, substrates, and conditions under which fixture work to be accomplished.

C. Correct any incorrect locations of piping and other unsatisfactory conditions for installation of plumbing fixtures.

D. Do not proceed with Work until unsatisfactory conditions corrected.

E. Do not use new fixtures during construction unless approved in writing by the Owner's Representative.

F. Contractor to CALL Underground Service Alert at 811 or submit a location request at call811.com at least two business days before digging fore trench http://www.socalgas.com/safety/dig-alert.shtml.

3.2 INSTALLATION GENERAL REQUIREMENTS

A. Provide, apply, install, connect, erect, clean, and condition manufactured materials and equipment as recommended in manufacturer's printed directions (maintained on job site during installation).

B. Provide all attachment devices and materials necessary to secure materials together or to other materials.

C. Make allowances for ample and normal expansion and contraction for all building components and piping systems that are not subject to such.

D. Install materials only when conditions of temperature, moisture, humidity and conditions of adjacent building components are conductive to achieving the best installation results.

E. Erect, install and secure components in a structurally sound and appropriate manner.

F. Where necessary, temporarily brace, shore, or otherwise support members until final connections are installed.

G. Leave all temporary bracing, shoring, or other structural supports in place as long as practical for safety and to maintain proper alignment.

H. Handle materials in a manner to prevent scratching, abrading, distortion, chipping, breaking or other disfigurement.

I. Conduct work in a manner to avoid injury or damage to previously placed work.

J. Any work so impaired or damaged shall be replaced at no expense to the Owner's Representative.

K. Fabricate and install materials true to line, plumb and level.

L. Leave finished surfaces smooth and flat, free from wrinkles, warps, scratches, dents and other imperfections.

M. Furnish materials in longest practical lengths and largest practical sizes to avoid all unnecessary jointing.

N. Make all joints secure, tightly fitted, and as inconspicuous as possible by the best, accepted practice in joinery and fabrication.

O. Consult the Owner's Representative for mounting or position of any unit not specifically indicated or located on drawings or specified in specifications.

P. Job mixed multi component materials used in the work shall be mixed in such regulated and properly sized batches that materials can be used before it begins to set.

Q. Mixing of a partially set batch with another batch of fresh materials will not be accepted and entire batch shall be discarded and removed from the site.

R. Clean all mixing tools and appliances that can be contaminated prior to mixing of fresh materials.

S. In addition to the above, refer to each section of the specifications for additional installation requirements for the proper completion of the work.

3.3 INSTALLATION OF PLUMBING FIXTURES

A. General: Install plumbing fixtures of types indicated where shown and at indicated heights, in accordance with fixture manufacturer's written instructions, roughing-in drawings, and recognized industry practices. Ensure plumbing fixtures comply with requirements and serve intended purposes. Comply with 2013 California Plumbing Code.

B. Installation

1. Set fixtures level and plumb. Secure in place to counters, floors and walls providing solid bearing and secure mounting. Bolt fixture carriers to floor and wall. Secure rough-in fixture piping behind or within wall to prevent movement of exposed piping.
2. Install each fixture with trap easily removable for servicing and cleaning. Install fixture stops in readily accessible location for servicing.
3. Install barrier free fixtures in compliance with ILHR 52 and Federal ADA Accessibility Guidelines. Install barrier free lavatory traps parallel and adjacent to wall and supplies and stops elevated to 27 inches above floor to avoid contact by wheelchair users.
4. Provide unions at water connections to drinking fountains and electric water coolers.
5. Cover pipe penetrations with escutcheons. Exposed traps, piping and escutcheons to be chrome plated brass. Cover exposed water closet bolts with bolt covers.
6. Seal openings between walls, floors and fixtures with mildew-resistant silicone sealant same color as fixture.
7. Protect fixtures during construction. At completion clean plumbing fixtures and trim using manufacturer's recommended cleaning methods and materials.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

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

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   2. Insulated Piping: One-piece, stamped-steel type.
   3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type.
   4. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type.
   5. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type.
   6. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
   7. Bare Piping at Floor Penetrations in Equipment Rooms: Split casting, floor-plate type.

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

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

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof 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 above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide minimum 1/2-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. Steel Pipe Sleeves: For pipes smaller than NPS 4.
   b. Steel Sheet Sleeves: For pipes NPS 4 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Section 07 92 00 – Joint Sealers.
      1) Seal space outside of sleeve fittings with grout.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 – Joint Sealers for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations
   1. Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   2. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 8413 – PENETRATION FIRE STOP SYSTEMS.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.5 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

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

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion

3.6 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric flanges to connect piping materials of dissimilar metals.
   4. Wet Piping Systems: Install dielectric flanges to connect piping materials of dissimilar metals.

3.7 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

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

3.8 DIELECTRIC FITTING INSTALLATION

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

3.9 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.10 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.11 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Sections 09 9100 – IPAINTING.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000 psi, 28-day compressive-strength concrete and reinforcement.

3.13 FIELD QUALITY CONTROL

A. Upon completion of installation and after units are water pressurized, test fixtures to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at site, then retest to demonstrate compliance, or remove and replace with new units and proceed with retesting.

B. Inspect each installed unit for damage to finish. If feasible, restore and match finish to original at site, or remove fixture and replace with new unit. Feasibility and match to be judged by the Owner’s Representative. Remove cracked or dented units and replace with new units.

3.14 ADJUSTING

A. Test fixtures to demonstrate proper operation. Replace malfunctioning units or components. Adjust self-closing lavatory faucets to 15 second cycle. Adjust shower valve temperature limit stops to 110 degree F maximum outlet temperature.

B. Adjust water pressure at drinking fountains, faucets, shower valves, and flush valves to provide proper flow stream and specified gpm without splashing, noise or overflow.

C. Adjust or replace washers to eliminate leaks at faucets or stops.

3.15 CLEANING

A. Clean plumbing fixtures, trim, and strainers of dirt debris upon completion of installation.

3.16 EXTRA STOCK

A. Furnish special wrenches and other devices necessary for servicing plumbing fixtures and trim to Owner’s Representative with receipt. Furnish 1 device for every 10 units.

3.17 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 5000 – METAL FABRICATIONS.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.18 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

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

3.19 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION

SECTION 220513
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

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

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 COORDINATION

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

PART 2 PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degrees C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

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

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. **Rated for minimum ABMA, L-10 life of 200,000 hours**. Calculate bearing load with NEMA minimum V- belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

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

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

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

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

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

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

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

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

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

2.6 SUBMITTALS

A. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

PART 3 EXECUTION

3.1 NOT USED

END OF SECTION

SECTION 220516
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cast-in-place concrete, cement, aggregates, water and admixtures.
      a. Subtext
         1) Subtext
            (a) Subtext

B. Related Sections:
   1. Section 031000 - Concrete Formwork.

1.2 RELATED DOCUMENTS

A. Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

1.3 SUMMARY

1. Section Includes
2. Flexible-hose packless expansion joints.
3. Metal-bellows packless expansion joints.
4. Grooved-joint expansion joints.
5. Pipe loops and swing connections.
6. Alignment guides and anchors.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.4 PERFORMANCE REQUIREMENTS

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

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

1.5 SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of expansion joint, from manufacturer.

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

F. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints
   1. Manufacturers:
      a. Flex-Hose Co., Inc.
      b. Or equal
   2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180 degree return bend or center section of flexible hose.
   3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
   4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
      a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 degrees F and 340 psig at 450 degrees F ratings.
   5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with flanged end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 degrees F and 225 psig at 450 degrees F ratings.
   6. Expansion Joints for Steel Piping NPS 2 and Smaller: Stainless-steel fittings with threaded end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 degrees F and 325 psig at 600 degrees F ratings.
   7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Stainless-steel fittings with flanged end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 degrees F and 145 psig at 600 degrees F ratings.
   8. Expansion Joints for Steel Piping NPS 8 to NPS 12: Stainless-steel fittings with flanged end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 degrees F and 90 psig at 600 degrees F ratings.

B. Metal-Bellows Packless Expansion Joints
   1. Manufacturers:
      a. Flex-Hose Co., Inc.
      b. Or equal.
   2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
   3. Type: Circular, corrugated bellows with external tie rods.
   4. Minimum Pressure Rating: 150 psig unless otherwise indicated.
   5. Configuration: Single joint class(es) unless otherwise indicated.
   6. Expansion Joints for Copper Tubing: Multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
      a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
      b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Flanged.
      c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

2.2 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers:
   1. Anvil International, Inc.
   2. Shurjoint Piping Products
   3. Flexonics Inc.
   4. Or equal

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Five, flexible type for steel-pipe dimensions. Include ferrous housing sections, EPDM gasket suitable for cold and hot water, and bolts and nuts.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides
   1. Manufacturers:
      a. Flex-Hose Co., Inc.
      b. Or equal
   2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials
   1. Steel Shapes and Plates: ASTM A 36/A 36M.
   2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
   3. Washers: ASTM F 844, steel, plain, flat washers.
   4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.
      a. Stud: Threaded, zinc-coated carbon steel.
      b. Expansion Plug: Zinc-coated steel.
      c. Washer and Nut: Zinc-coated steel.
   5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.
      a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
      b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
      c. Washer and Nut: Zinc-coated steel.

PART 3 EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

C. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments

1. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
3. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

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

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 220519
METERS AND GAGES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. Section Includes
   1. Bimetallic-actuated thermometers.
   2. Filled-system thermometers.
   3. Thermowells.
   4. Dial-type pressure gauges.
   5. Gauge attachments.
   6. Test plugs.
   7. Test-plug kits.
   8. Sight flow indicators.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 SUBMITTALS

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

B. Product Certificates: For each type of meter and gauge, from manufacturer.

C. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

PART 2 PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers:
   1. Marsh Bellofram.
   2. Weiss Instruments, Inc.
   3. Or equal

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type; stainless steel with 5-inch nominal diameter.

D. Dial: Non-reflective aluminum with permanently etched scale markings and scales in degrees F.

E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

F. Connector Size: 1/2-inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375-inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers:
   a. Marsh Bellofram.
   b. Weiss Instruments, Inc.
   c. Or equal
2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device rigid, back and rigid, bottom; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus 1 percent of scale range.

2.3 THERMOWELLS

A. Thermowells

1. Manufacturers:
   a. Marsh Bellofram.
   b. Weiss Instruments, Inc.
   c. Or equal
2. Standard: ASME B40.200.
3. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
4. Material for Use with Copper Tubing: CNR.
5. Material for Use with Steel Piping: CRES.
6. Type: Stepped shank unless straight or tapered shank is indicated.
7. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
8. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
9. Bore: Diameter required to match thermometer bulb or stem.
10. Insertion Length: Length required to match thermometer bulb or stem.
11. Lagging Extension: Include on thermowells for insulated piping and tubing.
12. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.4 PRESSURE GAUGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:

1. Manufacturers:
   a. Marsh Bellofram.
   b. Weiss Instruments, Inc.
   c. Or equal
2. Standard: ASME B40.100.

3. Case: Liquid-filled, Sealed, Open-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/2, ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

A. Manufacturers:
1. Miljoco Corporation.
2. Weiss Instruments, Inc.
3. Or equal

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

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

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

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

F. Core Inserts: EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

A. Manufacturers:
1. Weiss Instruments, Inc.
2. Watts Industries, Inc.; Water Products Div.
3. Or equal

B. Furnish one test-plug kit(s) containing two thermometers, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 degrees F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 degrees F.

E. Pressure Gauge: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

G. Install valve and snubber in piping for each pressure gauge for fluids.

H. Install test plugs in piping tees.

I. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.

J. Install pressure gauges in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

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

3.3 ADJUSTING

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater, heat exchanger and storage tanks and remote domestic water chiller.

1. Liquid-filled, Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.

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

3.5 THERMOMETER SCALE-RANGE SCHEDULE

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

B. Scale Range for Domestic Hot-Water Piping: 30 to 240 degrees F.

C. Scale Range for Solar Water Heating system Piping: 30 to 300 degrees F.

3.6 PRESSURE-GAUGE SCHEDULE

A. Provide pressure gauges at discharge of each water service into building.

1. Liquid-filled, Sealed, Open-front, pressure-relief, direct-mounted, metal case.

B. Provide pressure gauges at inlet and outlet of each water pressure-reducing valve.

1. Liquid-filled, Sealed, Open-front, pressure-relief, direct-mounted, metal case.

C. Provide pressure gauges at suction and discharge of each domestic water pumps and solar water heating system water pumps.

1. Liquid-filled, Sealed, Open-front, pressure-relief, direct-mounted, metal case.

3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 100 psi.

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

C. Scale Range for Solar Water Heating System Piping: 0 to 160 psi.

END OF SECTION

SECTION 220523
GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. Section Includes
   1. Bronze ball valves.
   2. Balancing valves
   3. Bronze lift check valves.
   4. Bronze swing check valves.
   5. Iron swing check valves with closure control.
   6. Bronze gate valves.
   7. Iron gate valves.
   8. Bronze globe valve
   9. Iron globe valve
   10. Drain valves

B. Related Sections
   1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
   2. Section 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT for valve tags and schedules.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Non-rising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

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

B. ASME Compliance

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

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

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

1.7 LEAD FREE INSTALLATION

A. The Contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the Owner's Representative for review.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types
   1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
   4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

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

F. Valve-End Connections
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   3. Solder Joint: With sockets according to ASME B16.18.
   4. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.
      d. Body Design: Two piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

2.3 BALANCING VALVES

A. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Copper-Alloy Calibrated Balancing Valves
   1. Manufacturers:
      a. Griswold.
      b. Bell & Gossett
      c. Or equal
   2. Type: Ball valve with two readout ports and memory setting indicator.
   3. Body: Bronze.
   4. Size: Same as connected piping, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.4 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Design: Vertical flow.
      d. Body Material: ASTM B 61 or ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

2.5 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

2.6 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Weight-Closure Control:
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.
      h. Closure Control: Factory-installed, exterior lever and weight.

2.7 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron.

2.8 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-70, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Disc: Solid wedge.
      g. Packing and Gasket: Asbestos free.

2.9 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.

g. Handwheel: Malleable iron.

2.10 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves
   1. Manufacturers:
      a. Nibco Inc.
      b. Or equal
   2. Description
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.
      g. DRAIN VALVES

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

C. Stop-and-Waste Drain Valves:
   1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
   2. Pressure Rating: 200-psig minimum CWP or Class 125.
   3. Size: NPS 3/4.
   4. Body: Copper alloy or ASTM B 62 bronze.
   5. Drain: NPS 1/8 side outlet with cap.

PART 3 EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

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

3.3 ADJUSTING

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

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball or gate valves.
   2. Throttling Service: Globe valves.
   3. Pump-Discharge Check Valves
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight.
      c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight.

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

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

3.5 DOMESTIC, INDUSTRIAL AND SOLAR HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller
   1. Valves may be provided with solder-joint ends instead of threaded ends.
   2. Bronze Ball Valves: Two piece, full port, bronze with stainless-steel trim.
   3. Bronze Swing Check Valves: Class 125, bronze disc.
   4. Bronze Gate Valves: Class 125, NRS.
   5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger
   1. Iron Valves, NPS 2-1/2 to NPS 3: May be provided with threaded ends instead of flanged ends.
   2. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
   3. Iron Gate Valves: Class 125, OS&Y.
   4. Iron Globe Valves: Class 125.

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller
   1. Bronze Swing Check Valves: Class 125, bronze disc.
   2. Bronze Gate Valves: Class 125, NRS.

B. Pipe NPS 2-1/2 and Larger

1. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
2. Iron Gate Valves: Class 125, OS&Y.

END OF SECTION

SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Fiberglass pipe hangers.
   4. Metal framing systems.
   5. Fiberglass strut systems.
   6. Thermal-hanger shield inserts.
   7. Fastener systems.
   8. Pipe positioning systems.
   9. Equipment supports.

B. Related Sections include the following:
   1. Section 055000 – METAL FABRICATIONS for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 21 Section "Wet Pipe Sprinkler Systems" for pipe hangers for fire-suppression piping.
   3. Section 220516 – EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING for pipe guides and anchors.
   4. Section 220548 – VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT for vibration isolation devices.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from Owner's Representative.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Fiberglass pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Powder-actuated fastener systems.

5. Pipe positioning systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Fiberglass strut systems. Include Product Data for components.
4. Pipe stands. Include Product Data for components.
5. Equipment supports.

C. Welding certificates.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel." AWS D1.4, "Structural Welding Code--Reinforcing Steel." ASME Boiler and Pressure Vessel Code: Section IX.

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. Tolco Inc.
2. Or equal

B. Carbon Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

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

B. Manufacturers:

1. Tolco Inc.
2. Or equal

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems

1. Manufacturers:
   a. Unistrut Corporation; Tyco International, Ltd.
   b. Or equal
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers:
   1. Pipe Shields, Inc.
   2. Or equal

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

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

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

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Powers Fasteners
      b. Or equal

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Powers Fasteners
      b. Or equal

2.6 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Manufacturers:
   1. C & S Mfg. Corp.
   2. Or equal

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
    1. Properties: Non-staining, non-corrosive, and non-gaseous.
    2. Design Mix: 5000 psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

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

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

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

E. Use fiberglass pipe hangers and fiberglass strut systems attachments for hostile environment applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

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

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

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
    2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 degrees F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
    3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
    4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
    5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
    6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
    7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
    8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
    9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
    10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
    11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
    12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
    13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
    14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
    15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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

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

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

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

P. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

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

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

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048-inch thick.
      b. NPS 4: 12 inches long and 0.06-inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06-inch thick.
      d. NPS 8: 24 inches long and 0.075-inch thick.
   5. Pipes NPS 8 and Larger: Include wood inserts.
   6. Insert Material: Length at least as long as protective shield.
   7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

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

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

3.4 METAL FABRICATIONS

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

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

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

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

3.5 ADJUSTING

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

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

3.6 PAINTING

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

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

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

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

END OF SECTION

SECTION 220548
VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
   10. Resilient pipe guides.
   11. Seismic snubbers.
   12. Restraining braces and cables.
   13. Steel, vibration isolation equipment bases.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading
   1. Refer to General Notes on Structural Drawings for site classification, building category and general load requirements.
   2. Refer to Table 13.6-1 in the ASCE 7-10 for equipment seismic coefficients for mechanical components.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or the applicable agency acceptable to Owner's Representative.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic-Restraint Details
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or the applicable agency acceptable to Owner’s Representative, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

D. Coordination Drawings: Show coordination of seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For professional engineer and testing agency.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner’s Representative.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis preapproved by ICC-ES, or preapproved by another agency acceptable to Owner’s Representative, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation
4. Isolation Technology, Inc.
5. Kinetics Noise Control
6. Or equal

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

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

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

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or limit-stop as required for equipment and Owner’s Representative.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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

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

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

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

J. Spring Hangers with Vertical Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

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

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

2.2 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation
3. Isolation Technology, Inc.
4. Kinetics Noise Control
5. Or equal

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.3 SEISMIC-RESTRAINT DEVICES

A. Manufacturers:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation
3. Cooper B-Line, Inc.; a division of Cooper Industries
4. Hilti, Inc.
5. Kinetics Noise Control
6. Loos & Co.; Cableware Division
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.
9. Or equal

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or the applicable agency acceptable to Owner’s Representative.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

D. Channel Support System: MFMA-3, shop or field fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

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

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or the applicable agency acceptable to Owner’s Representative.

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

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

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or the applicable agency acceptable to Owner’s Representative providing required submittals for component.

B. Piping Restraints

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.
4. Piping Isolation
5. Provide piping isolation as indicated in specification or as noted on drawings.
6. Unless otherwise specified, provide resilient support for all plumbing pipes throughout the building. No such piping is to come into rigid contact with the building.
7. Support all piping in mechanical equipment rooms on Type H2 or H3 springs sized for minimum 1-inch static deflection, unless otherwise noted.
8. Support all piping in Court Rooms, Conference /Meeting Rooms, Training Spaces, Judicial Chambers, Jury Deliberation Rooms, and Clerk Offices on Type H2 or H3 springs sized for minimum 1-inch static deflection, unless otherwise noted.
9. Support on vibration isolators all piping outside of mechanical equipment rooms which is connected to and within a 30-foot radius of a vibration-isolated piece of equipment. If the piece of equipment is supported on neoprene isolators, support pipes on Type B1 or H1 isolators sized for minimum 0.35-inch deflection. If the piece of equipment is supported on spring isolators, support pipes on Type B2 or H2 or H3 springs sized for minimum 1-inch deflection.
10. Throughout the rest of the building not covered in Paragraph 7 or 9 above, use RPS1 resilient pipe sleeves for support. An alternate to this is 1-inch-thick, 10 pcf-density glass fiber pipe insulation with suitable bearing plates to prevent crushing of insulation and without any steel pin or other rigid connection from plate to pipe through insulation.

C. Installation of Resilient Pipe Supports
1. Provide Type RPS1 or RPS2 or Custom resilient pipe sleeves wherever pipes penetrate construction.
2. Provide Type RPAG resilient pipe anchor/guide where anchors and / or guides are required in horizontal and vertical piping. Connect RPAG units to heavy structure only.
3. Release restraining washers and nuts in order to "free" all precompressed spring hangers.

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

E. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or the applicable agency acceptable to Owner’s Representative providing required submittals for component.

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

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

J. Provide neoprene pads under ears of riser clamps.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 0548 – VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT.

3.5 FIELD QUALITY CONTROL

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

B. Tests and Inspections
   1. Furnish evidence of recent calibration of test equipment by a testing agency acceptable to Owner’s Representative.
   2. Schedule test with the Owner’s Representative, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
   3. Obtain Owner’s Representative approval before transmitting test loads to structure. Provide temporary load-spreading members.
   4. Test at least four of each type and size of installed anchors and fasteners selected by the Owner’s Representative.
   5. Test to 90 percent of rated proof load of device.
   6. Measure isolator restraint clearance.
   7. Measure isolator deflection.
   8. Verify snubber minimum clearances.
   9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
   11. Test and adjust air-mounting system controls and safeties.
   12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of sprint isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Valve tags.
   5. Warning tags.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

F. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

1.4 COORDINATION

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

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

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

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. W.H. Bradley

B. Seton Inc.

C. D & G Sign and Label

D. Or Equal

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment
   1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   4. Fasteners: Stainless-steel rivets.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   2. Letter Color: Black.
   3. Background Color: White.
   4. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

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

2.3 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

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

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

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

G. Fasteners: Stainless-steel rivets.

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

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

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, showing flow direction and meeting the requirements of ASME (ANSI) Std. A13.1-2007.

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

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

D. Markers for underground plumbing piping: 6 mm thick, 3 inches wide, florescent yellow polyethylene tape with imprint to read “Caution – Buried Pipe Below”.

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

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size
   a. Pipes O.D. (including insulation) 1-3/8-inch and smaller: At least 1/2-inch high.
   b. Pipes O.D. (including insulation) greater than 1-3/8 inches but less than or equal to 3 inches: at least 1 inch.
   c. Pipes O.D. (including insulation) greater than 3 inches: at least 1-3/4 inches.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Jack chain.

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

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

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

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

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 09 9100 –PAINTING.

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

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

C. Pipe Label Color Schedule

   1. Use ASME/ANSI A13.1-2007 standard for pipe labeling.

3.4 VALVE-TAG INSTALLATION

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

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

   1. Valve-Tag Size and Shape
      a. 1-1/2 inches, round.
   2. Valve-Tag Color
      a. Natural.
   3. Letter Color
      a. Black.

3.5 STICK ON DOTS

A. Provide stick on dots on ceiling to locate equipment above T-bar type panel ceiling. Locate in corner of panel closest to equipment. Dots shall be blue for HVAC dampers, valves and terminal boxes, green for plumbing and red for controls.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 220700
PLUMBING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following:
   1. Insulation Materials
      a. Cellular glass.
      b. Flexible elastomeric.
      c. Mineral fiber.
   2. Insulating Cements
   3. Adhesives.
   4. Mastics.
   5. Lagging adhesives.
   6. Sealants.
   7. Field-applied fabric-reinforcing mesh.
   8. Field-applied jackets.
   9. Tapes.
   10. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

B. Related Sections include the following:
   1. Division 23 Section "HVAC Insulation."

1.3 SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section

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

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sample Sizes
      a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
      b. Sheet Form Insulation Materials: 12 inches square.
      c. Jacket Materials for Pipe: 12 inches long by NPS 2.
      d. Sheet Jacket Materials: 12 inches square.

   e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Qualification Data: For qualified Installer.

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

G. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: All insulation shall comply with fire and smoke hazard ratings indicated by ASTM E84, NFPA and UL. Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency Owner’s Representative. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Section 220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT.

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

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

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

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

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

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

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

   1. Products: provide one of the following:
      a. Pittsburgh Corning Corporation; Foamglas Super K.
      b. Cell-U-Foam Corporation; Ultra-CUF.
      c. Or equal
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Board Insulation: ASTM C 552, Type IV.
   5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

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

   1. Products: provide one of the following:
      a. Armacell LLC; AP Armaflex
      b. Aeroflex USA Inc.; Aerocel.
      c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180
      d. Or equal

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

   1. Products: provide one of the following:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      a. Johns Manville; Microlite.
      b. Knauf Insulation; Friendly Feel Duct Wrap.
      c. Manson Insulation Inc.; Alley Wrap.
      d. Owens Corning; SOFTR All-Service Duct Wrap.
      e. Or equal

H. Mineral-Fiber, Preformed Pipe Insulation

   1. Products: provide one of the following:
      a. Johns Manville; Micro-Lok
      b. Knauf Insulation; 1000 Pipe Insulation
      c. Owens Corning; Fiberglas Pipe Insulation
      d. Or equal
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket.

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

   1. Products: provide one of the following:
      a. Johns Manville; MicroFlex
      b. CertainTeed Corp.; CrimpWrap
      c. Knauf Insulation, Pipe and Tank Insulation
      d. Owens Corning; Fiberglas Pipe and Tank Insulation
      e. Or equal

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: provide one of the following:
   a. Insulco, Division of MFS, Inc.; Triple I.
   b. Ramco Insulation, Inc.; Super-Stik.
   c. Or equal

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: provide one of the following:
   a. Ramco Insulation, Inc.; Thermokote V.
   b. Or equal

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products: provide one of the following:
   a. Insulco, Division of MFS, Inc.; SmoothKote.
   b. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
   c. Rock Wool Manufacturing Company; Delta One Shot.
   d. Or equal

2.3 ADHESIVES

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

B. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.

1. Products: provide one of the following:
   a. Childers Products, Division of ITW; CP-96
   b. Foster Products Corporation, H. B. Fuller Company; 81-33.
   c. Or equal
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: provide one of the following:
   a. Aeroflex USA Inc.; Aeroseal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.
   e. Or equal
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: provide one of the following:
   a. Childers Products, Division of ITW; CP-82
   b. Foster Products Corporation, H. B. Fuller Company; 85-20.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.
   f. Or equal
2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: provide one of the following:
   a. Dow Chemical Company (The); 739, Dow Silicone.
   b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.

    d. Speedline Corporation; Speedline Vinyl Adhesive.
    e. Or equal
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
1. Products: provide one of the following:
    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    b. Vimasco Corporation; 749.
    c. Or equal
2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Products: provide one of the following:
    a. Childers Products, Division of ITW; CP-10.
    b. Foster Products Corporation, H. B. Fuller Company; 35-00.
    c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
    d. Marathon Industries, Inc.; 550.
    e. Mon-Eco Industries, Inc.; 55-50.
    f. Vimasco Corporation; WC-1/WC-5.
    g. Or equal
2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. Products: provide one of the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
    c. Vimasco Corporation; 713 and 714.
    d. Or equal
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 degrees F.
4. Color: White.

2.6 SEALANTS

A. Joint Sealants
1. Joint Sealants for Cellular-Glass:provide one of the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
    d. Mon-Eco Industries, Inc.; 44-05.

        e. Pittsburgh Corning Corporation; Pittseal 444.
        f. Or equal
    2. Materials shall be compatible with insulation materials, jackets, and substrates.
    3. Permanently flexible, elastomeric sealant.
    4. Service Temperature Range: Minus 100 to plus 300 degrees F.
    5. Color: White or gray.
    6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Metal Jacket Flashing Sealants:
    1. Products: provide one of the following:
        a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
        b. Eagle Bridges - Marathon Industries; 405.
        c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
        d. Mon-Eco Industries, Inc.; 44-05.
        e. Or equal
    2. Materials shall be compatible with insulation materials, jackets, and substrates.
    3. Fire- and water-resistant, flexible, elastomeric sealant.
    4. Service Temperature Range: Minus 40 to plus 250 deg F.
    5. Color: Aluminum.
    6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
    1. Products: provide one of the following:
        a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
        b. Or equal.
    2. Materials shall be compatible with insulation materials, jackets, and substrates.
    3. Fire- and water-resistant, flexible, elastomeric sealant.
    4. Service Temperature Range: Minus 40 to plus 250 degrees F.
    5. Color: White.
    6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
    1. Products: provide one of the following:
        a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.
        b. Vimasco Corporation; Elastafab 894.
        c. Or equal

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for equipment and pipe.
    1. Products: provide one of the following:
        a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
        b. Vimasco Corporation; Elastafab 894.
        c. Or equal

2.8 FIELD-APPLIED JACKETS

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

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: provide one of the following:
    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto PVC Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
    e. Or equal
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Owner’s Representative.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: provide one of the following:
    a. Childers Products, Division of ITW; Metal Jacketing Systems.
    b. PABCO Metals Corporation; Surefit.
    c. RPR Products, Inc.; Insul-Mate.
    d. Or equal
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Factory-Fabricated Fitting Covers:
        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: provide one of the following:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    b. Compac Corp.; 130.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    d. Venture Tape; 1506 CW NS.
    e. Or equal
2. Width: 3 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: provide one of the following:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    b. Compac Corp.; 120.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
    d. Venture Tape; 3520 CW.
    e. Or equal
2. Width: 2 inches.
3. Thickness: 3.7 mils.

4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
7. Tensile Strength: 34 lbf/inch in width.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 degrees F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use de-mineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

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

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

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

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

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

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 07 84 13 – Penetration Firestop Systems.

F. Insulation Installation at Floor Penetrations

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 – Penetration Firestop Systems.

3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

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

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

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

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

3.6 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

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

C. Insulation Installation on Pipe Fittings and Elbows
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties
1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

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

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

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

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

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

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

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

3.9 FIELD-APPLIED JACKET INSTALLATION

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

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

3.10 FINISHES

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

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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

C. Color: Final color as selected by Owner's Representative. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

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

B. Tests and Inspections

1. Inspect field-insulated equipment, randomly selected by Owner's Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
2. Inspect pipe, fittings, strainers, and valves, randomly selected by Owner's Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.12 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water: All piping exposed in plenums or above ceilings

1. NPS 1 1/4 and Smaller: Insulation shall be one of the following:
   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Hot Water Return, Industrial Hot and Hot Water Return, Tempered Water Supply and Return:: All piping

1. NPS 3/4 and Smaller: Insulation shall be one of the following:
   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1 and Larger: Insulation shall be one of the following:
   a. Cellular Glass: 1-1/2 inches thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 1/2 inch thick.

C. Industrial Cold Water and Irrigation Piping: All piping exposed in plenums or above ceilings
   1. NPS 1 1/4 and Smaller: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Sanitary Vents terminating through the roof:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.

E. Condensate and Equipment Drain Water below 60 Degrees F
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Degrees F
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic and Industrial Cold Water Piping: All piping above ceilings.
   1. NPS 1 1/4 and Smaller: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Flexible Elastomeric: 1 inch thick.
      c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Hot Water Return, Tempered Water Supply and Return: All piping
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 2 inches thick.
      b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material.

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

C. For vertical piping, provide 16 mil thick stucco embossed pattern finish, type 1100 aluminum jacket, ASTM B209. For horizontal pipe, locate lap on bottom. For fittings, provide 24 mil thick die shaped, smooth finish, type 1100jacket, ASTM B209. Provide 0.5” wide, 20 mil thick, Type 3003 alumnium bands on maximum 24” centers but less than two bands per jacket section.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material.

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

C. For vertical piping, provide 16 mil thick stucco embossed pattern finish, type 1100 aluminum jacket, ASTM B209. For horizontal pipe, locate lap on bottom. For fittings, provide 24 mil thick die shaped, smooth finish, type 1100jacket, ASTM B209. Provide 0.5” wide, 20 mil thick, Type 3003 alumnium bands on maximum 24” centers but less than two bands per jacket section.

END OF SECTION

SECTION 221116
PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Section 220500 – Common Work Results for Plumbing.

C. Refer to Section 083100 – Access Door and Panels.

1.2 SUMMARY

A. Section Includes

1. Under-building slab and aboveground water pipes, tubes, fittings, and specialties inside the building. This specification also applies to industrial water piping, irrigation piping inside the building and solar heating system piping.
2. Encasement for piping.
3. Specialty valves.
4. Flexible connectors.
5. Escutcheons.
6. Sleeves.
7. Sleeve seals.
8. Wall penetration systems.
9. Grout.

B. Related Section

1. General: Refer to Section 220500 - COMMON WORK RESULTS FOR PLUMBING.

C. Performance Requirements

1. Seismic Performance: Water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.3 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Flexible connectors.
3. Backflow preventers and vacuum breakers.

B. LEED Submittal

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

C. Water Samples: Specified in "Cleaning" Article.

D. Coordination Drawings: For piping in equipment rooms and other congested areas, provide drawings drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Plumbing piping.
3. Electrical conduit and devices.
4. HVAC hydronic piping and ductwork.

E. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.

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

1.5 PROJECT CONDITIONS

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

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

1.6 COORDINATION

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

1.7 LEAD FREE INSTALLATION

A. The contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the engineer for review.

PART 2 PRODUCTS

2.1 MATERIALS

A. Potable Water, Tempered Water and Non-Potable (Industrial) Water Piping

1. Above Grade
    a. All piping shall be hard drawn copper tubing, ASTM B88, Type K. Fittings for copper tubing shall be wrought copper.
2. Below Grade
    a. All piping shall be hard drawn copper tubing, ASTM B88, Type K. Fittings for copper tubing shall be wrought copper. Copper pipe to be pipe wrapped.

B. Natural Gas

1. Above Grade
    a. Low pressure and all medium pressure 2” and smaller shall be black steel pipe, Schedule 40, Type E or S, Grade B, ASTM A53; with black malleable iron threaded fittings, Class 150, ASTM A197/ANSI B16.3.
    b. Low pressure and all medium pressure 2-1/2 inches and larger shall be black steel pipe, Schedule 40, Type E or S, Grade B, ASTM A53; with seamless carbon steel weld fittings, ASTM A234 grade WPB/ANSI B16.9.
2. Natural Gas Vent, Above Grade
    a. 2” and smaller shall be galvanized steel pipe, Schedule 40, Type E or S, Grade B, ASTM A53; with black malleable iron threaded fittings, Class 150, ASTM A197/ANSI B16.3.
    b. 2-1/2 inches and larger shall be Galvanized steel pipe, Schedule 40, Type E or S, Grade B, ASTM A53; with seamless carbon steel weld fittings, ASTM A234 grade WPB/ANSI B16.9.

C. Dissimilar Piping Joints

1. Use non-conductive fittings whenever ferrous and non-ferrous piping materials are joined together.
2. Dielectric unions and couplings shall not be used.

D. Domestic or Industrial Water: Threaded M.P.S. minimum 3-inches long electro-zinc plated steel casing with inert NSF/FDA listed lining. ASTM F-492 rated at 225°F, 300 PSI. ClearFlow by Precision Plumbing Products Inc, or equal.

2.2 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Sheet or Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness.

D. Color: Black.

2.3 SPECIALTY VALVES

A. Comply with requirements in Section 22 05 23 – General Duty Valves for Plumbing Piping for general-duty metal valves.

B. Comply with requirements in Section 22 11 19 – Plumbing Water Piping Specialties for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.4 TRANSITION FITTINGS

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

2.5 DIELECTRIC FITTINGS

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

2.6 FLEXIBLE CONNECTORS

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

   1. Flex-Hose Co., Inc.

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

   1. Working-Pressure Rating: Minimum 200 psig.
   2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
   3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

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

   1. Working-Pressure Rating: Minimum 200 psig.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.7 ESCUTCHEONS

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

2.8 SLEEVES

A. General: Refer to Section 220500 – Common Work Results for Plumbing.

2.9 SLEEVE SEALS

A. General: Refer to Section 220500 – Common Work Results for Plumbing.

2.10 WALL PENETRATION SYSTEMS

A. General: Refer to Section 220500 – Common Work Results for Plumbing.

2.11 GROUT

A. General: Refer to Section 220500 – Common Work Results for Plumbing.

PART 3 EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 – Earth Moving for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

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

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

C. Install underground copper in PE encasement according to ASTM A 674 or AWWA C105.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each water service entrance. Comply with requirements in Section 220519 – Meters and Gages for Plumbing Piping for pressure gages and Section 221119 – Plumbing Water Piping Specialties for drain valves and strainers.

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

F. Install water piping level and plumb.

G. Install seismic restraints on piping. Comply with requirements in Section 220548 – Vibration and Seismic Controls for Plumbing Piping and Equipment for seismic-restraint devices.

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

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

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

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

L. Install piping to permit valve servicing.

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

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections. Notched tees (T-drill) are not acceptable. Use standard or reducing tees for branch connections.

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

Q. Install pressure gauges on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Section 220519 – Meters and Gages for Plumbing Piping for pressure gages.

R. Install thermostats in hot-water circulation piping. Comply with requirements in Section 221123 – Domestic Water Pumps for thermostats.

S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Section 220519 – Meters and Gages for Plumbing Piping for thermometers.

3.3 JOINT CONSTRUCTION

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

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

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

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

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

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

G. Pressure-sealed jointing system for copper piping are not acceptable and shall not be used.

H. Extruded tee connections are not acceptable and shall not be used.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 220523 – General Duty Valves for Plumbing Piping for valve installations.

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

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow.

3.5 TRANSITION FITTING INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.6 DIELECTRIC FITTING INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.7 FLEXIBLE CONNECTOR INSTALLATION

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

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

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

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 22 05 48 – Vibration and Seismic Controls for Plumbing Piping and Equipment for seismic restraint devices.

B. Comply with requirements Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.

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

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

3.9 CONNECTIONS

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

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

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

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

3.10 ESCUTCHEON INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.11 SLEEVE INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.12 SLEEVE SEAL INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.13 WALL PENETRATION SYSTEM INSTALLATION

A. General: Refer to Section 22 05 00 – Common Work Results for Plumbing.

3.14 IDENTIFICATION

A. Identify system components. Comply with requirements in Section 22 05 53 – Identification for Plumbing Piping and Equipment for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.15 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

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

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

E. Prepare test and inspection reports.

3.16 ADJUSTING

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

3.17 CLEANING

A. Clean and disinfect potable and non-potable water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Fill and isolate system according to either of the following:
   1) Fill system or part thereof with water / chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
   2) Fill system or part thereof with water / chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

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

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

3.18 PIPING SCHEDULE

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

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

C. Under-building-slab, building water service piping and irrigation piping, NPS 3 and larger, shall be the following:
   1. Hard copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints. Provide PE encasement.

D. Under-building-slab, plumbing and irrigation water piping, NPS 2-1/2 and smaller, shall be the following:
   1. Hard copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints. Provide PE encasement.

E. Aboveground domestic, industrial, irrigation and solar heating system water piping shall be the following:
   1. Hard copper tube, ASTM B 88, Type K, cast- or wrought- copper solder-joint fittings; and soldered joints.

3.19 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shut-off Duty: Use ball valves for piping NPS 2 and smaller. Use gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use globe valves for piping NPS 2 and smaller. Use globe valves with flanged ends for piping NPS 2-1/2 and larger.
   3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
   4. Drain Duty: Hose-end drain valves.

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

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

END OF SECTION

SECTION 221119
PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Water pressure-reducing valves.
   4. Temperature-actuated water mixing valves.
   5. Strainers.
   6. Hose bibbs.
   7. Wall hydrants.
   8. Water hammer arresters.
   9. Air vents.
   10. Trap-seal primer valves.
   11. Trap seal primer systems.

B. Related Sections include the following:
   1. Section 220519 – METERS AND GAGES FOR PLUMBING PIPING for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Section 221116 – PLUMBING PIPING.
   3. Section 224500 – EMERGENCY PLUMBING FIXTURES for water tempering equipment.
   4. Section 224700 – DRINKING FOUNTAINS AND WATER COOLERS for water filters for water coolers.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

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

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

E. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Inspector of Record, and marked for intended use.

B. NSF Compliance
   1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

1.6 LEAD FREE INSTALLATION

A. The Contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the Owner's Representative for review.

PART 2 PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers
   1. Manufacturers:
      a. Ames Co.
      b. ConBraCo Industries, Inc.
      c. FEBCO; SPX Valves & Controls
      d. Watts Industries, Inc.; Water Products Div.
      e. Or equal
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Body: Bronze.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers
   1. Manufacturers:
      a. Arrowhead Brass Products, Inc.
      b. ConBraCo Industries, Inc.
      c. Woodford Manufacturing Company
      d. Watts Industries, Inc.; Water Products Div.
      e. Or equal
   2. Standard: ASSE 1011.
   3. Body: Bronze, nonremovable, with manual drain.
   4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   5. Finish: Match hose bib material.

2.2 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers, RPBP-1, 2, 3 & 4
   1. Product:
      a. Ames Co.
      b. ConBraCo Industries, Inc.
      c. FEBCO; SPX Valves & Controls
      d. Watts Industries, Inc.; Water Products Div.
      e. Or equal
   2. Standard: ASSE 1013.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   5. Size: Refer to equipment schedule
   6. Design Flow Rate: Refer to equipment schedule
   7. Body: Lead free material. Bronze for NPS 2 and smaller; ductile iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   9. Configuration: Designed for horizontal, straight through flow.

10. Accessories
11. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
12. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Backflow-Preventer Test Kits
   1. Manufacturers:
      a. FEBCO; SPX Valves & Controls
      b. ConBraCo Industries, Inc.
      c. Flomatic Corporation
      d. Watts Industries, Inc.; Water Products Div.
      e. Or equal
   2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators
   1. Manufacturers:
      a. ConBraCo Industries, Inc.
      b. Watts Industries, Inc.; Water Products Div.
      c. Zurn Plumbing Products Group; Wilkins Div.
      d. Or equal
   2. Standard: ASSE 1003.
   3. Pressure Rating: Initial working pressure of 150 psig.
   4. Size: Refer to equipment schedule.
   5. Design Flow Rate: Refer to equipment schedule.
   6. Design Inlet Pressure: Refer to equipment schedule.
   7. Design Outlet Pressure Setting: Refer to equipment schedule.
   8. Body: Lead free material. Cast Bronze
   9. Valves for Booster Heater Water Supply: Include integral bypass.
   10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.4 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices, TMV-1
   1. Product:
      a. Bradley Corp.
      b. Leonard Valve Company
      c. Symmons Industries, Inc.
      d. Watts Industries, Inc.; Water Products Div.
      e. Zurn Plumbing Products Group; Wilkins Div.
      f. Or equal
   2. Standard: ASSE 1017.
   3. Pressure Rating: 125 psig.
   4. Type: Thermostatically controlled water mixing valve.
   5. Material: Bronze body with corrosion-resistant interior components.
   6. Connections: Threaded with unions on inlets and outlet.
   7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
   8. Tempered-Water Setting: Refer to equipment schedule.
   9. Tempered-Water Design Flow Rate: Refer to equipment schedule.
   10. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves, TMV-2 & 3
   1. Product:
      a. Bradley Corp.
      b. Lawler Manufacturing Company, Inc.
      c. Leonard Valve Company
      d. Powers; a Watts Industries Co.

e. Or equal
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig.
4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded inlets and outlet.
7. Accessories: Wall bracket, manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle, and inlet and outlet shut-off valves.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
9. Tempered-Water Setting: Refer to equipment schedule.
10. Tempered-Water Design Flow Rate: Refer to equipment schedule.
11. Valve Finish: Rough bronze.
12. Piping Finish: Copper.

2.5 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers Refer to equipment schedule for equipment type.
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Perforation Size
      a. Strainers NPS 2 and Smaller: 0.020-inch.
      b. Strainers NPS 2-1/2 to NPS 4: 0.045-inch.
      c. Strainers NPS 5 and larger: 0.10-inch.
   6. Drain: Pipe plug.

2.6 WALL HYDRANTS

A. Wall Hydrants, HB-1
   1. Manufacturers:
      a. Josam Company.
      b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      c. Woodford Manufacturing Company.
      d. Or equal
   2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
   3. Pressure Rating: 125 psig.
   4. Operation: Loose key.
   5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
   6. Inlet: NPS 3/4.
   7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
   8. Box: Deep, flush mounting with cover.
   9. Box and Cover Finish: Lockable Cover with Polished nickel bronze.
   10. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
   11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
   12. Operating Keys(s): One with each wall hydrant.

B. Moderate-Climate Wall Hydrants, HB-2
   1. Manufacturers:
      a. Josam Company.
      b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
      c. Woodford Manufacturing Company.
      d. Or equal
   2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
   3. Pressure Rating: 125 psig.
   4. Operation: Loose key.
   5. Inlet: NPS 3/4.

6. Outlet: Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounting with cover.
8. Box and Cover Finish: Lockable Cover with Polished nickel bronze.
9. Operating Keys(s): One with each wall hydrant.

2.7 WATER HAMMER ARRESTERS

A. Water Hammer Arresters.

1. Manufacturers:
   a. Sioux Chief Manufacturing Company, Inc.
   b. Or equal
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.8 AIR VENTS

A. Bolted-Construction Automatic Air Vents.

1. Body: Bronze.
2. Pressure Rating: 125 psig minimum pressure rating at 140 degrees F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.9 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves, TP-1

1. Manufacturers:
   a. Sioux Chief Manufacturing Company, Inc.
   b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   c. Watts Industries, Inc.; Water Products Div.
   d. Or equal
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Rough bronze.

2.10 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems, TP-2

1. Manufacturers:
   a. Sioux Chief Manufacturing Company, Inc.
   b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   c. Watts Industries, Inc.; Water Products Div.
   d. Or equal
2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
4. Cabinet: Recessed-mounting steel box with stainless-steel cover. Provide fire-rated box when installed in fire rated walls.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: Refer to drawings, maximum 4 drains served using distribution units.
8. Size Outlets: NPS 1/2.
9. Electrical Requirements: 0.33 amps, 120 volts-60 Hertz

B. Trap-Seal Primer Systems, TP-3

1. Manufacturers:
    a. Sioux Chief Manufacturing Company, Inc.
    b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    c. Watts Industries, Inc.; Water Products Div.
    d. Or equal
2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
4. Cabinet: Recessed-mounting steel box with stainless-steel cover. Provide fire-rated box when installed in fire rated walls.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: Refer to drawings, maximum 10 drains served.
8. Size Outlets: NPS 1/2.
9. Electrical Requirements: 0.33 amps, 120 volts-60 Hertz

PART 3 EXECUTION

3.1 INSTALLATION

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with 2013 California Plumbing Code.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

C. Install water regulators with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.

D. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install thermometers and water regulators if specified.
   2. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

F. Install water hammer arresters in water piping according to PDI-WH 201. Provide at every branch to multiple fixtures for both cold and hot water piping. Install in ceiling as indicated in drawings or where it would be difficult to fit the device in the wall.

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

H. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow. Install trap-seal primer valves behind access panels. Access panels shall have an opening sized 18”x18” minimum for non-full body access.

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

3.2 CONNECTIONS

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

B. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

C. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.3 LABELING AND IDENTIFYING

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

1. Reduced-pressure-principle backflow preventers.
2. Water pressure-reducing valves.
3. Primary, thermostatic, water mixing valves.
4. Supply-type, trap-seal primer valves.
5. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each vacuum breaker and reduced-pressure-principle backflow assembly according to DWP and the device's reference standard.

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

3.5 ADJUSTING

A. Set field-adjustable pressure setpoints of water pressure-reducing valves.

B. Set field-adjustable temperature setpoints of temperature-actuated water mixing valves.

END OF SECTION

SECTION 221123
DOMESTIC WATER PUMPS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Section 220500 – Common Work Results for Plumbing.

C. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. Section Includes
   1. Horizontally mounted, in-line, close-coupled centrifugal pumps.
   2. Vertically mounted, in-line, close-coupled centrifugal pumps.

B. Related Sections include the following:
   1. Section 221123.13 Domestic Water Packaged Booster Pumps for booster systems.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

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

1.7 COORDINATION

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

1.8 LEAD FREE INSTALLATION

A. The contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the engineer for review.

PART 2 PRODUCTS

2.1 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Armstrong Pumps Inc.
   2. Bell & Gossett Domestic Pump; ITT Corporation.
   3. PACO Pumps; Grundfos Pumps Corporation, U.S.A.
   4. TACO Incorporated.
   5. Or equal

B. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.

C. Pump Construction
   1. Casing: Radially split with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
   2. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
   3. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
   4. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
   5. Bearings: Oil-lubricated; bronze-journal or ball type. **Rated for minimum ABMA, L-10 life of 200,000 hours**. Calculate bearing load with NEMA minimum V- belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
   6. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

D. Motor: Single speed, with grease-lubricated ball bearings; and resiliently or rigidly mounted to pump casing.

E. Capacities and Characteristics
   1. Capacity: Refer to equipment schedule.
   2. Total Dynamic Head: Refer to equipment schedule.
   3. Casing Material: Bronze.
   4. Impeller Material: ASTM B 584, cast bronze.
   5. Minimum Working Pressure: 175 psig.
   6. Maximum Continuous Operating Temperature: 225 deg F.
   7. Inlet and Outlet Size: Refer to equipment schedule.
   8. Pump Control: Thermostat and timers.
   9. Pump Speed: Refer to equipment schedule.
   10. Motor Horsepower: Refer to equipment schedule.
   11. Electrical Characteristics:
       a. Volts: Refer to equipment schedule.
       b. Phases: Refer to equipment schedule.
       c. Hertz: 60.

2.2 VERTICALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Armstrong Pumps Inc.
   2. Bell & Gossett Domestic Pump; ITT Corporation.
   3. PACO Pumps; Grundfos Pumps Corporation, U.S.A.
   4. TACO Incorporated.
   5. Or equal.

B. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.

C. Pump Construction

1. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
2. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.
4. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
5. Bearings: Oil-lubricated; bronze-journal or ball type.
6. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.

D. Motor: Single speed, with grease-lubricated ball bearings; and rigidly mounted to pump casing.

E. Capacities and Characteristics

1. Capacity: Refer to equipment schedule.
2. Total Dynamic Head: Refer to equipment schedule.
3. Casing Material: Bronze.
4. Impeller Material: ASTM B 584, cast bronze.
5. Minimum Operating Pressure: 175 psig.
6. Maximum Continuous Operating Temperature: 225 deg F.
7. Inlet and Outlet Size: Refer to equipment schedule.
8. Pump Control: Thermostat and timers.
9. Pump Speed: Refer to equipment schedule.
10. Motor Horsepower: Refer to equipment schedule.
11. Electrical Characteristics
    a. Volts: Refer to equipment schedule.
    b. Phases: Refer to equipment schedule.
    c. Hertz: 60.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 05 13 – Common Motor Requirements for Plumbing Equipment.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.4 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 degrees F.
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 120 V, ac.
7. Settings: Start pump at 105 deg F and stop pump at 121 deg F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, Type 1. Suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 120 V, ac.
6. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install horizontally mounted, in-line, close-coupled centrifugal pumps with shaft(s) horizontal.

C. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.

D. Pump Mounting: Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using elastomeric pads. Comply with requirements for concrete base specified in Section 03 30 00 – Cast-in-Place Concrete.
   1. Minimum Deflection: 1/4-inch.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support pump weight.
   1. Comply with requirements for vibration isolation devices specified in Section 22 05 48 – Vibration and Seismic Controls for Plumbing Piping and Equipment. Fabricate brackets or supports as required.
   2. Comply with requirements for hangers and supports specified in Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment.

F. Install pressure switches in water supply piping.

G. Install thermostats in hot-water return piping.

H. Install timers on wall in engineer's office.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 – Domestic Water Piping. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
   1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
      a. Horizontally mounted, in-line, close-coupled centrifugal pumps.
      b. Vertically mounted, in-line, close-coupled centrifugal pumps.
      c. Comply with requirements for flexible connectors specified in Section 22 11 16 – Domestic Water Piping.
   2. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Section 22 05 23 – General Duty Valves for Plumbing Piping and comply with requirements for strainers specified in Section 22 11 19 – Domestic Water Piping Specialties.

3. Install pressure gauge and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gauge tappings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 22 05 19 – Meters and Gauges for Plumbing Piping

D. Comply with Division 26 Sections for electrical connections, and wiring methods.

E. Connect thermostats, and timers to pumps that they control.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Section 22 05 53 – Identification for Plumbing Piping and Equipment for identification of pumps.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, timers, for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:
    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.6 ADJUSTING

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

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION

SECTION 221223
FACILITY INDOOR POTABLE WATER STORAGE TANKS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Section 220500 – Common Work Results for Plumbing.

1.2 SUMMARY

A. This Section includes potable-water storage tanks and related accessories for indoor installation.

1.3 DEFINITIONS

A. HDPE: High-density polyethylene plastic.

B. LDPE: Low-density polyethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories. Indicate dimensions, wall thickness, insulation, finishes and coatings, required clearances, methods of assembly of components, and piping connections.

B. Manufacturer Seismic Qualification Certification: Submit certification that indicated steel, potable-water storage tanks, accessories, and components will withstand seismic forces defined in Section 220548 – Vibration and Seismic Controls for Plumbing Piping and Equipment.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Manufacturer Certificates: Signed by manufacturers certifying that potable-water storage tanks comply with requirements.

D. Source quality-control test reports.

E. Purging and disinfecting reports.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of potable-water storage tanks and are based on the specific system indicated. Refer to Section 016000 – Product Requirements.

B. ASME Compliance for Steel Tanks: Fabricate and label steel, potable-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 LEAD FREE INSTALLATION

A. The contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the engineer for review.

PART 2 PRODUCTS

2.1 PLASTIC, NONPRESSURE, POTABLE-WATER STORAGE TANKS

A. PE Potable-Water Storage Tanks:
   1. Manufacturers: Subject to compliance with requirements, provide products by Snyder Industries, Inc. or one of the following:
      a. Amprotec, Inc.; Tank System Division.
      b. Assmann Corporation of America.
      c. Chem-Tainer Industries.
      d. Poly Processing Company.
      e. Premier Plastics Inc.
      f. Steel Tank and Fabricating.
      g. TolPlast Company, Inc.
      h. Or approved equal
   2. Description: PE, vertical, flat-bottom, nonpressure-rated water tank; complying with NSF 61 barrier materials for potable-water tanks.
   3. Construction: ASTM D 1998, molded PE.
   4. Tappings: Factory-fabricated bulkhead fittings attached to tank.
      a. NPS 2 and Smaller: With female thread.
      b. NPS 2-1/2 and Larger: Flanged.
   5. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting entire bottom of tank.

B. Manhole: Watertight, for tank more than 36 inches in diameter.

C. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.

D. Specialties and Accessories: Include tappings in the tank and the following:
   1. Vacuum relief valve.
   2. Free air vent with insect screen.

2.2 STEEL, PRECHARGED, POTABLE-WATER STORAGE TANKS, DT-1 & ET-1:

A. Steel, Precharged, Bladder, Water Storage Tanks
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or equal product by one of the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett
      c. Flo Fab inc.
      d. Taco, Inc.
      e. Wessels Company
      f. Or Approved equal.
   2. Description: Steel, vertical, pressured-rated tank with cylindrical sidewalls and with air-charging valve and air precharge.
   3. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
   4. Operation: Factory-installed, butyl-rubber bladder.
   5. Construction: ASME code, steel, constructed with nontoxic welded joints, for 150-psig working pressure.
   6. Tappings: Factory-fabricated steel, welded to tank before testing and labeling.
      a. NPS 2 and Smaller: ASME B1.20.1, with female thread.
      b. NPS 2-1/2 and Larger: ASME B16.5, flanged.
   7. Specialties and Accessories: Include tappings in tank and the following:

   a. Pressure gauge.
8. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.
9. Tank Interior Finish: Materials and thicknesses complying with NSF 61 barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.
   a. Lining Material: Cement.
   b. Coating: Epoxy resin.
10. Exterior Coating: Manufacturer's standard enamel paint.

2.3 SOURCE QUALITY CONTROL

A. Test and inspect potable-water storage tanks according to the following tests and inspections and prepare test reports:
   1. Pressure Testing for ASME-Code, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop in pressure, and check for leaks. Replace tanks that fail test with new tanks, and repeat until test is satisfactory.
   2. Testing for Nonpressure, Potable-Water Storage Tanks: Fill tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two hours with no drop in water level

B. Repair or replace tanks that fail test with new tanks, and repeat until test is satisfactory.

PART 3 EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases of dimensions indicated for tanks. Refer to Section 22 05 00 – Common Work Results for Plumbing.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported tanks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported tanks.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.2 INSTALLATION

A. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

B. Anchor tank supports and tanks to substrate.
   1. Use steel or FRP straps over or around plastic tanks.

C. Install tank seismic restraints.

D. Install thermometers and pressure gauges on water storage tanks and piping, if indicated. Thermometers and pressure gages are specified in Section 22 05 19 – Meters and Gages for Plumbing Piping.

E. Install combination temperature and pressure relief valves in top portion of pressure storage tanks. Use relief valves with sensing elements that extend into tanks. Extend relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor sink.

F. Install the following devices on tanks where indicated:
   1. Connections to accessories.

G. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.3 CONNECTIONS

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

B. Install piping adjacent to potable-water storage tanks to allow service and maintenance.

C. Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

1. General-duty valves are specified in Section 22 05 23 – General Duty Valves for Plumbing Piping.
   a. Valves NPS 2 and Smaller: Ball.
   b. Valves NPS 2-1/2 and Larger: Gate.
   c. Drain Valves: NPS 3/4 ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.
2. Water Piping Connections: Make connections to dissimilar metals with dielectric fittings. Dielectric fittings are specified in Section 22 05 00 – Common Work Results for Plumbing.

3.4 FIELD QUALITY CONTROL

A. Perform the following final checks before filling:

1. Verify that air precharge in precharged tanks is correct.
2. Test operation of tank accessories and devices.
3. Verify that pressure relief valves have correct setting.
   a. Manually operate pressure relief valves.
   b. Adjust pressure settings.

B. Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

3.5 CLEANING

A. Clean and disinfect potable-water storage tanks.

B. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, use procedure described in AWWA C652 or as described below:

1. Purge water storage tanks with potable water.
2. Disinfect tanks by one of the following methods:
   a. Fill tanks with water-chlorine solution containing at least 50 ppm of chlorine. Isolate tanks and allow to stand for 24 hours.
   b. Fill tanks with water-chlorine solution containing at least 200 ppm of chlorine. Isolate tanks and allow to stand for three hours.
3. Flush tanks, after required standing time, with clean, potable water until chlorine is not present in water coming from tank.
4. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination made by authorities having jurisdiction shows evidence of contamination.

C. Prepare written reports for purging and disinfecting activities.

END OF SECTION

SECTION 221315
CONDENSATE DRAIN PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

B. Refer to Section 083100 – ACCESS DOORS AND PANELS.

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods and specialties for the following:

   1. Condensate Drain Piping

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 SUBMITTALS

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

   1. Condensate-Drain Piping Material

B. Submittals: Contractor to submit proof of certification.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

A. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

PART 2 PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: Type L.

B. Cast-Copper Fittings: ASME B16.18.

2.2 DIELECTRIC FITTINGS

A. General: Refer to Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS

A. Condensate-Drain Piping: Type L copper tubing, cast-copper fittings, and soldered joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at minimum 1% slope.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

3.3 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Section 22 0548   Vibration and Seismic controls for Plumbing Piping and Equipment.

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

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4-inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4-inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

END OF SECTION

SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Encasement for underground metal piping.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. LLDPE: Linear, low-density polyethylene plastic.

C. NBR: Acrylonitrile-butadiene rubber.

D. PE: Polyethylene plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.
   2. Sanitary Sewer, Force-Main Piping: 100 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

C. Shop Drawings
   1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

1.7 PROJECT CONDITIONS

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

PART 2 PRODUCTS

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

A. Pipe and Fittings: ASTM A 74, Extra Heavy class.

B. Gaskets: ASTM C 564, rubber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

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

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
      a. Manufacturers
         1) ANACO.
         2) Mission Rubber Co.
         3) Tyler Pipe; Soil Pipe Div.
         4) Or equal

2.3 SPECIAL PIPE FITTINGS

A. Shielded, Non-pressure, Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers
      a. Cascade Waterworks Mfg. Co.
      b. Mission Rubber Co.
      c. Or equal

B. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   1. Manufacturers
      a. Cascade Waterworks Mfg. Co.
      b. Dresser, Inc.; DMD Div.
      c. EBAA Iron Sales, Inc.
      d. JCM Industries, Inc.
      e. Romac Industries, Inc.
      f. Smith-Blair, Inc.
      g. Viking Johnson.
      h. Or equal
   2. Center-Sleeve Material: Manufacturer's standard.
   3. Gasket Material: Natural or synthetic rubber.
   4. Metal Component Finish: Corrosion-resistant coating or material.

2.4 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105

B. Material: Linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Sheet or tube

D. Color: Black

PART 3 EXECUTION

3.1 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.

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Basic piping installation requirements are specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

K. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 220548 – VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT.

L. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8 bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

N. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow unless otherwise indicated on drawings.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow unless otherwise indicated on drawings.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

O. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

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

Q. Install engineered soil and waste drainage and vent piping systems as follows:
   1. Combination Waste and Vent: Comply with standards of California Plumbing Code.

R. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
   1. Install encasement on piping according to ASTM A 674 or AWWA C105.

S. Install force mains at elevations indicated.

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

U. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

V. Install cleanouts in the building for gravity drain piping so that they are accessible and the cleanouts located behind walls must be piped above the fixture flood rim level to avoid spillage of effluent in wall cavity when cleanouts are opened to clear blockage.

W. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

Y. Do not enclose, cover, or put piping into operation until it is inspected and approved by Inspector of Record.

3.3 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 0500 – COMMON WORK RESULTS FOR PLUMBING.

B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

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

D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in OD's.
   2. In Drainage Piping: Shielded, non-pressure transition couplings.
   3. In Aboveground Force Main Piping: Fitting-type transition couplings.
   4. In Underground Force Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2 and Larger: Pressure transition couplings.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 22 05 23 – General Duty Valves for Plumbing Piping.

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.

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

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

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Backwater valve are specified in Section 22 1319 – SANITARY WASTE PIPING SPECIALTIES.

3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 22 0548 – VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT.

B. Pipe hangers and supports are specified in Section 22 0529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Section 220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT.

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

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

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

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

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

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

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

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

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

3.7 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by 2013 California Plumbing Code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by 2013 California Plumbing Code.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by 2013 California Plumbing Code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves in pit with pit cover flush with floor.
6. Comply with requirements for backwater valves, cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
7. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To interior gravity building drain with inlet above pipe or sanitary manhole.
2. Sewage Pumps: To sewage pump discharge.

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

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

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

3.8 IDENTIFICATION

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

3.9 FIELD QUALITY CONTROL

A. During installation, notify Inspector of Record at least 72 hours before inspection must be made. Perform tests specified below in presence of Inspector of Record.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by Inspector of Record to observe tests specified below and to ensure compliance with requirements.

B. Re-inspection: If Inspector of Record find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

C. Reports: Prepare inspection reports and have them signed by Inspector of Record.

D. Test sanitary drainage and vent piping according to procedures of Inspector of Record or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of California Plumbing Code or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 CLEANING

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

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

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

3.11 PIPING SCHEDULE

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

B. Aboveground, storm water piping shall be the following:
1. Hubless cast-iron soil pipe and fittings; NSP certified CISPI stainless-steel couplings; and hubless-coupling joints.
2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground, storm water piping shall be any the following:
1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

END OF SECTION

SECTION 221319
SANITARY WASTE PIPING SPECIALTIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Clean Outs.
   2. Roof flashing assemblies.
   3. Through-penetration firestop assemblies.
   4. Miscellaneous sanitary drainage piping specialties.
   5. Flashing materials.
   6. Oil Interceptors.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene plastic.

D. PE: Polyethylene plastic.

E. PP: Polypropylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
   1. Backwater valves.
   2. Cleanouts.
   3. Floor drains.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof penetrations.

1.7 EXTRA MATERIALS

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

PART 2 PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts, WCO:

1. Manufacturers:
   a. Zurn
   b. Josam Company; Josam Div.
   c. MIFAB, Inc.
   d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Or equal
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, bronze plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Vandal Proof Screws

B. Metal Floor Cleanouts, FCO:

1. Manufacturers:
   a. Zurn
   b. Josam Company; Josam Div.
   c. MIFAB, Inc.
   d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Or equal
2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Spigot for lowest floor or hubless for upper floors.
8. Closure: Bronze plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Vandal Proof screws

2.2 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Fire stop Assemblies
   1. Manufacturers:
      a. ProSet Systems Inc.
      b. Or equal
   2. Standard: UL 1479 assembly of sleeve and stack fitting with fire stopping plug.
   3. Size: Same as connected soil, waste, or vent stack.
   4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
   5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
   6. Special Coating: Corrosion resistant on interior of fittings.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

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

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

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

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

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

2.4 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
   3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

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

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

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40 mil minimum thickness.

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

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

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

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

PART 3 EXECUTION

3.1 INSTALLATION

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING for piping joining materials, joint construction, and basic installation requirements.

B. Install end of line backwater valves at each waste inlet to the sewage ejector vault.

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

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

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

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall. Install cleanouts above the flood level rim of fixtures to prevent effluent spillage into wall cavity when pipe is opened for cleaning.

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

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

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

H. Install through-penetration fire stop assemblies for stacks at floor penetrations.

I. Install floor-drain and floor sink, trap-seal primer fittings on inlet to floor drains and floor sinks that require trap-seal primer connection.

1. Size: Same as floor drain inlet. Refer to floor plans for location.

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

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

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

M. Install oil interceptors, including trapping, venting, and flow-control fitting, according to California Plumbing Code and with clear space for servicing.

1. Flush with Floor Installation: Set unit and extension with cover flush with finished floor.

2.5 CONNECTIONS

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

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

C. Oil Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping.

2.6 FLASHING INSTALLATION

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

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

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

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

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

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

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

2.7 LABELING AND IDENTIFYING

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

1. PH Monitor Panel
2. Sampling Tank

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT.

2.8 PROTECTION

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

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

END OF SECTION

SECTION 221413
FACILITY STORM DRAINAGE PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Section 220500 – Common Work Results for Plumbing.

1.2 SUMMARY

A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. LLDPE: Linear, low-density polyethylene plastic.

B. PE: Polyethylene plastic.

C. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

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

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

C. Shop Drawings
   1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   2. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Extra Heavy class.

B. Gaskets: ASTM C 564, rubber.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

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

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

1. NSF Certified CISPI Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
    a. Manufacturers
        1) ANACO.
        2) Mission Rubber Co.
        3) Tyler Pipe; Soil Pipe Div.
        4) Or Approved Equal
2. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
    a. Manufacturers
        1) ANACO.
        2) Mission Rubber Co.
        3) Tyler Pipe; Soil Pipe Div.
        4) Or Approved Equal

2.4 RECTANGULAR DRAIN PIPE AND FITTINGS

A. Pipe and Fittings: City of LA Approved, Research Report RR-5094.

B. Reinforced fiberglass pipe and fittings with manufacturer approved bonded joint and transition fittings.

1. Manufacturers
    a. Superior Pipe Co. or approved equal.

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall Perforated PVC Pipe: ASTM D 2729, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2729, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.

1. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Solvent Cement: ASTM D 2564.

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

2.6 SPECIAL PIPE FITTINGS

A. Shielded, Non-pressure, Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers
   a. Cascade Waterworks Mfg. Co.
   b. Mission Rubber Co.
   c. Or approved equal.

B. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   1. Manufacturers
      a. Cascade Waterworks Mfg. Co.
      b. Dresser, Inc.; DMD Div.
      c. EBAA Iron Sales, Inc.
      d. JCM Industries, Inc.
      e. Romac Industries, Inc.
      f. Smith-Blair, Inc.
      g. Viking Johnson
      h. Or approved equal
   2. Center-Sleeve Material: Manufacturer's standard.
   3. Gasket Material: Natural or synthetic rubber.
   4. Metal Component Finish: Corrosion-resistant coating or material.

2.7 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105

B. Material: Linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Sheet or tube

D. Color: Black

PART 3 EXECUTION

3.1 EXCAVATION

A. Refer to Section 312000 – Earth Moving for excavating, trenching, and backfilling.

B. PIPING INSTALLATION

C. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

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

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

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

G. Install piping to permit valve servicing.

H. Install piping at indicated slopes.

I. Install piping free of sags and bends.

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

K. Storm sewer and drainage piping outside the building are specified in Section 334100 – Storm Utility Drainage Piping.

L. Basic piping installation requirements are specified in Section 220500 – Common Work Results for Plumbing.

M. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 220548 – Vibration and Seismic Controls for Plumbing Piping and Equipment.

N. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

P. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

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

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

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

S. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Section 221423 – Storm Drainage Piping Specialties.

T. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 220500 – Common Work Results for Plumbing.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 – Common Work Results for Plumbing

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

3.2 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

C. Plastic, Non-pressure Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.3 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Shielded, non-pressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:
   a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
   b. NPS 2 and Larger: Pressure transition couplings.

3.4 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523 – General Duty Valves for Plumbing Piping.

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

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

D. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Install backwater valves in accessible locations.
   3. Backwater valve are specified in Section 22 14 23 – Storm Drainage Piping Specialties.

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 220548 – Vibration and Seismic Controls for Plumbing Piping and Equipment.

B. Pipe hangers and supports are specified in Section 220529 – Hangers and Supports for Plumbing Piping and Equipment. Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs: According to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Section 220529 – Hangers and Supports for Plumbing Piping and Equipment.

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

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

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.
   5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

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

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

3.6 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

3.7 FIELD QUALITY CONTROL

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

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

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

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.

3.8 CLEANING

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

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

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

3.9 PIPING SCHEDULE

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

B. Aboveground, storm water piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings; NSP certified CISPI stainless-steel couplings; and hubless-coupling joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground, storm water piping shall be any the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

END OF SECTION

SECTION 221423
STORM DRAINAGE PIPING SPECIALTIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Section 220500 – Common Work Results for Plumbing.

1.2 SUMMARY

A. This Section includes the following storm drainage piping specialties:
   1. Roof Drains
   2. Overflow Roof Drains
   3. Backwater Valves
   4. Trench Drains
   5. Planter Drains
   6. Area Drains
   7. Gutter Drains
   8. Clean Outs
   9. Through-penetration fire stop assemblies.
   10. Miscellaneous storm drainage piping specialties.
   11. Flashing materials.
   12. Overflow Drain Outlet Cover

B. Related Sections include the following:
   1. Section 221319 – Sanitary Waste Piping Specialties for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer, air admittance valves, FOG disposal systems, grease interceptors and removal devices, oil interceptors, and solid interceptors.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PUR: Polyurethane plastic.

H. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data
   1. Roof Drains.
   2. Overflow Roof Drains.
   3. Backwater Valves.
   4. Trench Drains.
   5. Planter Drains.
   6. Area Drains.
   7. Gutter Drains.
   8. Clean Outs

9. Through-penetration fire stop assemblies.
10. Miscellaneous storm drainage piping specialties.
11. Flashing materials.
12. Overflow Drain Outlet Cover.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 PRODUCTS

2.1 ROOF AND OVERFLOW DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by Zurn Industries. or equal product by one of the following:
   1. Josam Company.
   2. Smith, Jay R. Mfg. Co.
   3. Tyler Pipe; Wade Div.
   4. Or approved equal

B. Roof Drain: RD-1
   1. Description: Dura coated Cast Iron body, 15-inch diameter body, combination membrane flashing clamp, gravel guard, no hub outlet, underdeck clamp, sump receiver and adjustable extension sleeve.
   2. Dome Type: Low silhouette cast iron dome.
   3. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

C. Roof Drain: RD-2
   1. Description: Dura coated Cast Iron body, 15-inch diameter body, combination membrane flashing clamp, gravel guard, no hub outlet, underdeck clamp, sump receiver and adjustable extension sleeve.
   2. Dome Type: Low silhouette cast iron dome.
   3. 3-inch outlet.

D. Overflow Roof Drain: ORD-1
   1. Description: Dura coated Cast Iron body, 15-inch diameter body, combination membrane flashing clamp, gravel guard, no hub outlet, underdeck clamp, sump receiver, 2” high external water dam and adjustable extension sleeve.
   2. Dome Type: Low silhouette cast iron dome.
   3. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

E. Overflow Roof Drain: ORD-2
   1. Description: Dura coated Cast Iron body, 15-inch diameter body, combination membrane flashing clamp, gravel guard, no hub outlet, underdeck clamp, sump receiver, 2” high external water dam and adjustable extension sleeve.
   2. Dome Type: Low silhouette cast iron dome.
   3. 3-inch outlet.

2.2 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves, BSV-1:
   1. Manufacturers: Subject to compliance with requirements, provide Zurn Z-1090-BV or equal product by one of the following:
      a. Josam Company
      b. MIFAB, Inc.
      c. Smith, Jay R. Mfr. Co.
      d. Tyler Pipe; Wade Div.

e. Watts Drainage Products Inc.
2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.3 TRENCH DRAINS

A. Manufacturers: Subject to compliance with requirements, provide Zurn Z-665 or equal product by one of the following:
   1. Josam Company
   2. MIFAB, Inc.
   3. Smith, Jay R. Mfg. Co.
   4. Tyler Pipe; Wade Div.
   5. Watts Drainage Products Inc.
   6. ACO Polymer Products, Inc.
   7. Or approved equal

B. Trench Drain: TD-1
   1. Description: Dura coated Cast Iron body, modular extensions as required by trench length, gasket outlet connection and dome bottom strainer.
   2. Grate type: 12-inch wide, heel proof secured polished bronze grate.
   3. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

2.4 PLANTER DRAINS

A. Manufacturers: Subject to compliance with requirements, provide Smith, Jay R. Mfg. Co. 1935Y. or equal product by one of the following:
   1. Josam Company.
   2. Zurn Industries.
   3. Tyler Pipe; Wade Div. Or approved equal
   4. Or approved equal

B. Planter Drain: PD-1
   1. Description: Dura coated Cast Iron body, 12-inch diameter body, underdeck clamp, flashing clamp and stainless steel perforated gravel stop with 3/8” diameter openings, secured solid cover and polyethylene dome.
   2. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

C. Planter Drain: OPD-1
   1. Description: Dura coated Cast Iron body, 12-inch diameter body, underdeck clamp, flashing clamp and stainless steel perforated gravel stop with 3/8” diameter openings, secured solid cover, 2-inch high PVC standpipe and polyethylene dome.
   2. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

D. Planter Drain: PD-2
   1. Description: Dura coated Cast Iron body, 12-inch diameter body, underdeck clamp, flashing clamp and stainless steel perforated gravel stop with 3/8” diameter openings, secured solid cover and polyethylene dome.
   2. 3-inch outlet minimum. Verify pipe size connection indicated on floor plans.

E. Planter Drain: OPD-2
   1. Description: Dura coated Cast Iron body, 12-inch diameter body, underdeck clamp, flashing clamp and stainless steel perforated gravel stop with 3/8” diameter openings, secured solid cover, 2-inch high PVC standpipe and polyethylene dome.
   2. 3-inch outlet minimum. Verify pipe size connection indicated on floor plans.

2.5 AREA DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by Mifab Inc. or equal product by one of the following:
   1. Josam Company.
   2. Zurn Industries.
   3. Smith, Jay R. Mfg. Co.
   4. Tyler Pipe; Wade Div.
   5. Watts Drainage Products Inc.
   6. Or approved equal

B. Promenade Deck Drain: AD-1
   1. Description: Dura coated Cast Iron body with square promenade frame, combination membrane clamp, sediment bucket gasket outlet connection.
   2. Grate Type: 15-inch square nickel bronze, medium duty, heel proof grate.
   3. 4-inch outlet minimum. Verify pipe size connection indicated on floor plans.

C. Promenade Deck Drain: AD-2
   1. Description: Dura coated Cast Iron body with square promenade frame, combination membrane clamp, sediment bucket gasket outlet connection.
   2. Grate Type: 8-inch square nickel bronze, medium duty, heel proof grate.
   3. 3-inch outlet.

2.6 GUTTER DRAINS

A. Manufacturers: Subject to compliance with requirements, provide Zurn Z-181-BS-HD or equal product by one of the following:
   1. Josam Company
   2. MIFAB, Inc.
   3. Smith, Jay R. Mfg. Co.
   4. Tyler Pipe; Wade Div.
   5. Watts Drainage Products Inc.
   6. Or approved equal

B. Gutter Drain: GD-1
   1. Description: Dura coated Cast Iron body, 6-inch diameter body, membrane clamp, no hub outlet.
   2. Dome Type: 5-3/4 inch high plain bronze slotted dome strainer with mesh screen.
   3. 3-inch outlet minimum. Verify pipe size connection indicated on floor plans.

2.7 DOWNSPOUT NOZZLE

A. Manufacturers: Subject to compliance with requirements, provide Zurn Z-199-SS or equal product by one of the following:
   1. Josam Company
   2. MIFAB, Inc.
   3. Smith, Jay R. Mfg. Co.
   4. Tyler Pipe; Wade Div.
   5. Watts Drainage Products Inc.
   6. Or approved equal

B. Down Spout Nozzle: DS-1. Overflow nozzle ODS-1 as applicable.
   1. Description: Nickel Bronze body, threaded inlet.
   2. Wall Flange: Decorative face of wall flange and outlet nozzle.
   3. 3-inch outlet minimum. Verify pipe size connection indicated on floor plans.

2.8 CLEANOUTS

A. Exposed Metal Cleanouts, WCO:
   1. Manufacturers: Subject to compliance with requirements, provide Zurn Z1446-BP-VP or equal product by one of the following:

a. Josam Company; Josam Div.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, bronze plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Vandal Proof Screws

B. Metal Floor Cleanouts, FCO:
1. Manufacturers: Subject to compliance with requirements, provide Zurn ZN1400-BP-HD-KC-VP or equal product by one of the following:
   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Spigot for slab on grade installation or hubless for upper floors.
8. Closure: Bronze plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Vandal Proof screws

2.9 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Fire stop Assemblies
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with fire stopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.10 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

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

2.11 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft..
2. Vent Pipe Flashing: 8 oz./sq. ft..

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

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40 mil minimum thickness.

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

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

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

G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.12 OVERFLOW DRAIN OUTLET COVER

A. Manufacturers: Subject to compliance with requirements, provide Zurn Z-199-DC or equal product by one of the following:

1. Josam Company
2. MIFAB, Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.

B. Overflow drain outlet cover: ODC-1.

1. Description: Round fabricated stainless steel frame with fabricated secured perforated stainless steel hinged strainer.
2. Vandal proof secured top.

PART 3 EXECUTION

3.1 INSTALLATION

A. Refer to Section 220500 – Common Work Results for Plumbing for piping joining materials, joint construction, and basic installation requirements.

B. Install a backwater valve at the outlet of the subsoil drain discharge from the building. Locate the valve in a valve pit. Provide pit with airtight cover centered over backwater valve and of adequate size to access valve for servicing.

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

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

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

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

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

G. Install through-penetration fire stop assemblies in plastic conductors and stacks at floor penetrations.

H. Install roof and overflow drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

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

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

K. Install overflow drain outlet cover on overflow drains where they spill onto grade. Spill thru building wall at 10” above grade unless otherwise indicated on architects drawings.

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

3.2 CONNECTIONS

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

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

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

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

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

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

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

END OF SECTION

SECTION 222000
LABORATORY PLUMBING

PART 1 GENERAL

1.1 INTENT OF LABORATORY PLUMBING SPECIFICATION SECTION

A. The intent of this section is to provide information which is supplemental to all other divisions and sections of the specifications, and in particular to Division 22 Plumbing work, which shall be specifically related to the plumbing construction within the areas defined under the Laboratory scope of work. It is not intended to make any deletions, either explicitly or implicitly, to any of the other division or section requirements, and these sections do not relieve the Contractor from complying in all respects with other divisions and sections of the specifications. The other divisions and sections shall be considered to be an integral part of the Laboratory Plumbing work and shall be modified only as defined herein. Any questions the Contractor has with respect to the intent of the Laboratory Plumbing work sections should be addressed during the bidding period. Clarifications will be provided upon written request.

1.2 WORK INCLUDED

A. Provide complete plumbing systems from point of rough-in and final connections as described in these specifications and as shown on the Contract Drawings. Plumbing installations shall include all piping, valves, connectors and miscellaneous equipment to provide complete operable systems, in accordance with the best practices of the trade.

B. Except as modified by this section, all products, equipment, installation procedures, and general conditions contained within Division 22 Plumbing sections of these specifications applies to work specified in this section.

C. Work under this section includes, but is not limited to, installation of branch supply piping from main piping systems to points of termination within the laboratories, as well as laboratory waste and vent piping from between floor and ceiling.

D. Work NOT included under this section is as follows:
   1. Laboratory waste piping below point of connection at the floor slab
   2. Laboratory vent piping beyond point of connection above ceiling
   3. Building distribution main piping systems
   4. Fire sprinkler systems
   5. Steam and condensate piping systems

1.3 RELATED WORK DESCRIBED ELSEWHERE

A. General and Supplementary Conditions and Division 1

B. Section 019113 – General Commissioning Requirements

C. Section 115310 – Laboratory Casework and Other Furnishings

D. Section 115313 – Fume Hoods and Other Air Containment Units

E. Section 115343 – Laboratory Service Fittings and Fixtures

F. Section 115350 – Laboratory Equipment

G. Division 22 – Plumbing

H. Division 23 – Heating Ventilating and Air Conditioning

I. Division 26 – Electrical

1.4 REFERENCES

A. In addition to complying with all applicable trade and building codes and regulations, comply with applicable portions of the National Sanitation Foundation (NSF) standards.

1.5 DEFINITIONS

A. Above Finished Floor: Inside building within a zone usually considered at ± 6" above floor finish.

B. Above Finished Ceiling: Inside building within a zone usually considered at ± 6" above ceiling finish.

C. Below Slab: Located in ceiling space of floor below, buried in ground, or embedded in concrete slab on ground.

D. Concealed: Inside building, above grade and located within walls, furred spaces, service cores, pipe drop enclosures, above suspended ceilings, etc. In general any item not visible or directly accessible.

E. Connect: Complete hookup of item with required services, including all adapters and fittings.

F. Exposed: Either visible or subject to mechanical or weather damage, indoors or outdoors, including areas such as mechanical and storage rooms. In general any item that is directly accessible without removing panels, walls, ceiling or other parts of structure commonly used as reference to surface mounted piping, etc.

G. Point of Connection: Point within a piped system at which responsibility of this section either begins or ends. i.e. laboratory waste begins at fixture outlet and ends at Point of Connection (P.O.C.) ± 6" above floor finish. From there to be continued on Plumbing Drawings, and remainder of Division 22 specifications.

H. UHP: Ultra-High Purity

1.6 CLOSING IN UNINSPECTED WORK

A. Do not cover or enclose work prior to testing, inspection, and approval. All work covered or enclosed prior to approval and acceptance shall be re-opened. All finishes shall be restored.

1.7 SUBMITTALS

A. Submit as specified herein and under provisions of Division 1 “Submittal Requirements”.

B. Submittal shall be complete with all product data specified herein and organized by specification section in one binder. All submitted product data shall be referenced to the applicable paragraph number contained within this specification section.

C. Manufacturer’s Data: Submit complete materials list, including catalog data, of all materials, equipment, and products for work in this section.

D. Shop Drawings: Submit coordinated shop drawings depicting the work specified herein for actual fabrication and installation. Work shall be coordinated with other trades and building structural and architectural elements. Shop drawings shall include plans, elevations, and sections as required depicting the intended installation and final product. Drawings shall be electronically prepared in AutoCAD or similar software and submitted in a complete package with minimum ¼ inch = 1 ft scale format and maximum sheet size of Architectural “E” (30” x 42”).

1.8 RECORD DRAWINGS

A. The Contractor shall maintain an up-to-date set of “red-line” prints, marked to indicate progress of the Project and all as-built conditions. Prints shall be updated on a daily basis, and shall be available for review at all times on the job site.

B. Record Drawings shall indicate locations of all equipment and pipe rerouting, as well as any changes in locations or positions of equipment.

C. Comply with Division 1 “Project Closeout” for Record Drawings requirements.

1.9 SUBSTITUTIONS

A. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where “Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.

B. Substitution shall not affect dimensions shown on Drawings.

C. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.

D. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.

E. Maintenance and service parts shall be locally available for the proposed substitution.

PART 2 PRODUCTS

2.1 PIPING AND FITTINGS

A. Domestic and Industrial Cold, Hot, and Tepid Water:

1. Provide copper piping as specified in Section 221116.
2. Flexible Connectors: Provide 150 psi WOG working pressure rating, single braid, and stainless steel hose with threaded end connections. Manufacturers: US Hose Corp., Hyspan, or approved equal.
3. Flexible Tubing: Provide ASTM B 88 Type L, soft, annealed, seamless copper tubing.
4. Water Hammer Arrestors: Provide ASSE 1010, ANSI A112.26.1, or PDI-WH 201 certified copper tube with piston arrestor constructed of Type K or L hard drawn copper body, brass piston with lubricated dual O-ring seals, and threaded wrought copper or brass MIP connector. Manufacturers: PPP Inc., Sioux Chief, or approved equal.

B. Purified Water:

1. Provide polypropylene piping as specified in Section 226700.
2. Pipe shall be cleaned and capped at time of manufacture.
3. Provide continuous (linear piping) tray-type channel support (“V” or “U” shaped sheet metal or fiberglass) along entire horizontal ceiling distribution of piping system.
4. Fixture Flexible Connectors: Pure water 3/8” O.D. polypropylene tubing with polypropylene threaded compression fittings. Grab ring or slip compression type fittings are not acceptable.

C. Vacuum:

1. Provide copper piping as specified in Section 226213.
2. Threaded joints in distribution piping shall be limited to connections to pressure/vacuum indicators, alarm devices, and source equipment. All threads shall be tapered pipe threads complying with ANSI B1.20.1 and be made up with polytetrafluoroethylene (such as Teflon™) tape or other thread sealant, with the sealant applied to the male threads only. Where threaded nipples are required these shall be I.P.S. brass.
3. Flexible Connectors: Provide 150 psi WOG working pressure rating, single braid, stainless steel hose with threaded end connections. Manufacturers: US Hose Corp., Hyspan, or approved equal.

D. Compressed Air:

1. Provide copper piping as specified in Section 226113.
2. Threaded joints in distribution piping shall be limited to connections to pressure/vacuum indicators, alarm devices, and source equipment. All threads shall be tapered pipe threads complying with ANSI B1.20.1 and be made up with polytetrafluoroethylene (such as Teflon™) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only. Where threaded nipples are required these shall be I.P.S. brass.
3. Flexible Connectors: Provide 150 psi WOG working pressure rating, single braid, stainless steel hose with threaded end connections. Manufacturers: US Hose Corp., Hyspan, or approved equal.

E. Laboratory (Natural) Gas:

1. Provide black steel piping as specified in Section 221116.
2. Flexible Connectors: Provide corrugated stainless steel tubing (CSST) connectors in locations indicated on the Laboratory Plumbing drawings. CSST shall comply with ANSI/AGA Standard LC-1 and bear an IAPMO classified marking. CSST tubing one-piece constructed of high tensile

strength austenitic stainless steel with polymer or polyethylene coating. Nuts and fitting shall be constructed of zinc-plated steel or brass.

a. Manufacturers:
   1). BrassCraft Manufacturing
   2). Tru-Flex Metal Hose Corporation
   3). Omega Flex Inc.
   4). Titeflex Corporation
   5). Ward Manufacturing
   6). Or approved equal
b. All products specified in this section shall be the provided by a single manufacturer.
c. Length:
   1). Provide 18 inch long at all laboratory gas service valve cocks and P.O.C.s to fume hoods.
   2). Provide 24 inch long connections at ADA adjustable hoods and work stations.

F. Laboratory Waste and Vent:

1. Provide flame-retardant polypropylene (PP) piping as specified in Section 226600.
   a. Joints:
      1). Polypropylene (PP), fusion weld, per manufacturer's instructions. Installed behind walls, partitions, inaccessible ceiling spaces etc., unless otherwise noted.
      2). Polypropylene (PP), mechanical joint, per manufacturer's instructions. Installed in areas exposed to view, accessible ceiling spaces, fixture P-trap connections (both ends), and areas subject to ease of retrofit of the system.
      3). Mechanical joints within sink cabinets and other areas exposed to view shall be threaded or grooved style piping joints. Compression bands shall not be used in these locations.
2. Provide chrome-plated brass waste piping for tailpiece, P-trap, and trap arm at exposed-to-view locations for installations of emergency eyewash Laboratory fixtures and wall-hung hand wash sinks.

2.2 VALVES

A. Domestic and Industrial Cold, Hot, and Tepid Water:

1. Fixture Supply Stop Valves:
   a. Provide angle pattern, ¼-turn ball, loose key with lockshield supply stop valve. Brass body and stem chrome plated, metal oval key handle. Provide chrome finished metal escutcheon, 250 psi/250°F rating, 1/2-inch FIP inlet x 3/8-inch O.D. outlet. Manufacturers: BrassCraft, Dahl, or approved equal.
2. Shutoff Valves:
   a. Provide bronze ball valve as specified in Section 220523.
3. Check Valves:
   a. Provide swing check valves as specified in Section 220523.
4. Vacuum Breakers: Provide vacuum breakers on potable water services as accepted by local building Authority and as specified in Section 221119.
5. Back Flow Preventers: Provide reduced-pressure-principle backflow preventers on potable water services supplying laboratory equipment, as accepted by local building Authority, and as specified in Section 221119.
6. Pressure regulators: Provide adjustable water pressure regulators service fitting connection size and as specified in Section 221119.
7. Ice Maker Water Valve Box:
   a. Provide all-metal recessed wall box fabricated of minimum 20-gauge steel with steel faceplate. Provide white epoxy powder coated finish. Approximate overall dimensions: 7-inch wide x 7-inch high x 3-inch deep.
   b. Valve box equipped with quarter turn, angle pattern, brass, stop ball valve with ½-inch MIP x ¼-inch compressing connections with integral top mounted water hammer arrestor.
   c. Manufacturers: LSP Products Group model OB-509 or approved equal.
8. Industrial Hot/Cold Water Valve Box (Painted Steel):
   a. Provide recessed wall box fabricated of minimum 20-gauge steel with white epoxy powder coated finish. Approximate overall dimensions: 14-inch wide x 9-inch high x 3-inch deep.
   b. Valve box to be equipped with hot water and cold water fittings as required for equipment services.

c. Manufacturers: Guy Gray Manufacturing Company model T150 or approved equal (no known equal).

B. Purified Water:

1. Control, Branch and Shut-off Valves:
   a. Provide polypropylene ball valves as specified in Section 226700.
2. Water Valve Box Assembly:
   a. Valve Box:
      1). Provide recessed wall box fabricated of minimum 20-gauge steel with white epoxy powder coated finish. Minimum clear interior dimensions: 6-inch wide x 6-inch high x 3-inch deep.
      2). Manufacturers: Guy Gray Manufacturing Co. model BIM875, LSP Products Group model OB-509 less valve, or approved equal.
   b. Valve:
      1). Valve box to be provided with polypropylene needle valve with Teflon PTFE seal. Valve to be provided with ½" FNPT inlet and ¼" or ½" NPT outlet.
      2). Manufacturers: Marquest Scientific model NA-500-PPR, WaterSaver model L73100F-1/4PP, or approved equal.

C. Vacuum:

1. Shutoff Valves:
   a. Provide bronze ball valve as specified in Section 226213.

D. Compressed Air:

1. Shutoff Valves:
   a. Provide bronze ball valve as specified in Section 226113.
2. Pressure Regulators: Provide pressure regulator with pressure gauge, adjustable from 10 to 120 psi, at compressed air point of connection to laboratory. Manufacturers: Norgren Excelon 73, Watts R10, or approved equal.

E. Laboratory (Natural) Gas:

1. Shutoff Valves:
   a. Provide bronze ball valve as specified in Section 231123.
2. Zone Shutoff Valve Box:
   a. Provide recessed zone valve box assembly consisting of the following components: minimum 16-gauge steel recessed valve box with white baked enamel finish, flush box door, continuous concealed door hinge, and 7.5" x 5.5" vision panel. Provide recessed zone valve box assembly with flush paddle handle latch, lock and key is not acceptable. Approximate recessed dimensions: 12-inch wide x 12-inch high x 4-inch deep.
      1). Identification:
         a). Zone valve box to be provided with engraved plastic label "LABORATORY GAS CONTROL VALVE", "CLOSE ONLY IN EMERGENCY". Engraved label to have white lettering on black label.
   b. Manufacturers: Acudor model ARVB or approved equal.

2.3 DISPOSERS

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.

1. In-Sink-Erator, http://www.insinkerator.com/
2. Waste King by Anaheim Manufacturing, http://anaheimmfg.com/
3. Approved equal.

B. Basis of Design: In-Sink-Erator Model Evolution Excel, 1.0 HP motor, auto-reverse disposer.

C. Description:

1. Features:
   a. ON/OFF switch for wall mounting above sink
   b. Stainless steel grind chamber and components. Unit finish to be stainless steel.
   c. Anti-vibration mount, quiet collar sink baffle, sound insulation.

2. Provide sink flange assembly for 3½ inch to 4 inch sink opening, 1½ inch waste connection, and dishwasher drain connection.
3. Unit shall be 120V single phase motor.

2.4 PROTECTIVE PIPE COVER (AT EXPOSED P-TRAP ARMS)

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.
   1. Truebro, Inc., http://www.ipscorp.com/truebro
   2. Approved equal

B. Basis of Design: Truebro LAV GUARD undersink protective pipe cover.

C. Description; Flexible, molded, antimicrobial, closed cell vinyl pipe cover and fittings for P-trap, angle valve, tailpiece, extension arm, supply tube, etc. components below sink.

D. Material Characteristics:
   1. Wall thickness: 1/8 inch (3 mm)
   2. Durometer: 60 – 70 Shore A
   3. Finish: Smooth high gloss
   4. Color: White
   5. UV Protection: Will not fade or discolor
   6. Flame Characteristics (ASTM D 635): 0 sec. (ATB), 0 mm (AEB)
   7. Thermal conductivity (K value): 1.17 plus dead air space

E. Features:
   1. Fasteners: Reusable snap clips
   2. Protective wrap shall install without disassembling plumbing
   3. Latching covers to access angle stops
   4. Removable cleanout nut for servicing

2.5 INSULATION

A. Insulate laboratory piping as specified in Section 220700 for the respective systems.

2.6 PIPING HANGERS, SUPPORTS AND GUIDE

A. Provide hangers and supports as specified in Section 220529.

2.7 PIPING AND EQUIPMENT IDENTIFICATION

A. Provide identification for plumbing piping and equipment as specified in Section 220553.

PART 3 EXECUTION

3.1 CONNECTION

A. Connect laboratory piping to P.O.C. valves shown on Plumbing drawings and to laboratory services. Provide threaded couplings at final connection to service fittings and valve stops.

B. Laboratory Waste and Vent:
   1. Laboratory Waste: Connect laboratory fixture/outlet waste to P.O.C. of laboratory waste. Extend piping from tail piece connector with trap and trap arm,
   2. Laboratory Vent: Connect fixture trap arm to P.O.C. of laboratory vent.

3.2 INSTALLATION

A. Domestic and Industrial Cold, Hot, and Tepid Water:
   1. Extend piping from P.O.C. to services as indicated on LP-series drawings. Provide threaded couplings at final connection to service fittings and valve stops.

2. Install approved pressure regulators on laboratory equipment connections when required by equipment manufacturer. Set delivery pressure within equipment manufactures' specifications.
3. Install water hammer arrestors on water piping that serves quick closing or solenoid operated valves for equipment or laboratory services. Water hammer arrestors shall be installed upstream of these valves in accordance with manufacturer's recommendations.
4. Fixture Connection: Install supply stop valve for each service to fixture as indicated on LP-series drawings. Install flexible connector or flexible tubing from valve to fixture supply water connections.
5. Extend tepid domestic water piping from P.O.C. to drench hoses and safety shower/eyewash units as indicated on LP-series drawings.
6. Refer to corresponding sections of Division 22 for system cleaning and disinfecting requirements.

B. Purified Water:
   1. Extend piping from P.O.C. to services as indicated on LP-series drawings.
   2. Fixture Connection: Install supply shutoff valve for each fixture as indicated on LP-series drawings. Install flexible tubing from valve to fixture supply water connection.
   3. Cleaning:
      a. Refer to corresponding sections of Division 22 for system cleaning and disinfecting requirements.
      b. If not specified elsewhere, minimum requirements shall be to flush and disinfect new water lines with "MINNCARE" or equal cleaning solution.

C. Laboratory Vacuum:
   1. Extend piping from P.O.C. to services as indicated on LP-series drawings.
   2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on LP-series drawings.
   3. Cleaning:
      a. Refer to corresponding sections of Division 22 for system cleaning requirements.

D. Compressed and Laboratory Air:
   1. Extend piping from P.O.C. to services as indicated on LP-series drawings.
   2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on LP-series drawings.
   3. Copper Tubing Brazing Procedures:
      a. Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 538°C (1000°F). Copper-to-copper joints shall be brazed using a copper–phosphorus–silver brazing filler metal (BCuP series) without flux. Flux shall only be used when brazing dissimilar metals such as copper and bronze or brass, using a silver (BAg series) brazing filler metal. Brazing alloy comply with ANSI/AWS A.5.8 Specification for Brazing Filler Metal. Residual flux on interior surfaces of tubing and fittings must be completed removed with cleaning processes.
      b. While being brazed, all piping joints shall be continuously purged with oil-free, dry Nitrogen to prevent the formation of copper oxide on the inside surfaces of the joint. The purge shall be maintained until the joint is cool to the touch.

E. Laboratory (Natural) Gas:
   1. Extend piping from P.O.C. to services as indicated on LP-series drawings.
   2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on LP-series drawings.
   3. Installation Standards: Install gas piping in accordance with recommendations of NFPA 54.
   4. Install in-line shutoff valves at locations and per details shown on LP-series drawings.

F. Laboratory Waste and Vent:
   1. Install horizontal pipe with uniform slope of 1/4-inch per foot (minimum).
   2. Use reduction fittings, not bushings, to connect pipes of different diameters.
   3. Change direction by appropriate use of 45-degree wyes, long sweep quarter-bends, and sixth-, eighth-, and sixteenth-bends.
   4. All fixture traps shall be of the "P" type with mechanical joints for removal.

5. No vent shall intersect another vent at a point less than six inches above the extreme overflow level of the highest fixture served unless said fixtures are located back to back, in which a sanitary "TEE" may be used.
6. Vents shall be taken off the top half of horizontal runs and shall be graded so as will quickly drain any water or condensate.

3.3 TESTS

A. Contractor shall thoroughly test all Work prior to operation in the presence of Owner's Representative. Any Work showing faults under test shall be replaced. Contractor shall maintain an accurate written record of all tests and test results, and shall submit three copies of all final tests to the Owner's Representative.

B. Refer to Division 22 specifications for system test requirements. If not specified elsewhere, minimum requirements shall be as follows:
   1. Domestic Cold, Hot, and Tepid Water: Test under a cold water hydrostatic pressure of 150 psig for a period of four (4) hours and carefully check for leaks. Repair all leaks and re-test system until proven watertight with no loss of pressure or leakage allowed.
   2. Purified Water: Do not conceal any piping until satisfactorily tested. Test and prove tight under a hydrostatic pressure of 100 psi for a period of four (4) hours and carefully check for leaks. Repair all leaks and re-test system until proven watertight with no loss of pressure or leakage allowed.
   3. Laboratory Vacuum: Test and prove airtight under an air pressure of 50 psig for a period of four (4) hours and bubble test all joints with a soap solution. Following pressure test, perform vacuum hold test pressure of -25” Hg for a period of four (4) hours with a maximum vacuum degradation of 1.25” Hg allowed. Repair all leaks and re-test system until proven airtight.
   4. Compressed and Laboratory Air: Test and prove airtight under an air pressure of 150 psig for a period of four (4) hours and bubble test all joints with a soap solution. Repair all leaks and re-test system until proven airtight with no loss of pressure or leakage allowed.
   5. Laboratory (Natural) Gas: Test and prove gas-tight under an air pressure of 50 psig for a period of four (4) hours and bubble test all joints with a soap solution. Repair all leaks and re-test system until proven gas-tight with no loss of pressure or leakage allowed. Make a final 24-hour standing pressure test with air at 20 psig before connecting equipment. Retest the system until it is proven free of leaks.

END OF SECTION

SECTION 223400
FUEL FIRED DOMESTIC WATER HEATERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

B. Refer to General Commissioning Requirements on Section 019113

1.2 SUMMARY

A. This Section includes the following fuel-fired water heaters:
   1. Commercial, grid-type, finned-tube, gas-fired, domestic-water heaters.
   2. Expansion tanks.
   3. Water heater accessories.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

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

D. Product Certificates: For each type of commercial, gas fired water heater, signed by product manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Section 220548 – VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT. Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

I. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to California Plumbing Code, and marked for intended use.

B. ASHRAE/IESNA 90.1-2004Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

C. ASME Compliance
   1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

D. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.

B. Failures include, but are not limited to, the following:
   1. Structural failures including storage tank and supports.
   2. Faulty operation of controls.
   3. Deterioration of metals, metal finishes, and other materials beyond normal use.
   4. Warranty Period(s): From date of Substantial Completion
      a. Commercial, Finned-Tube, Gas Fired, Domestic Water Heaters
         1) Heat Exchanger: Three years.
         2) Controls and Other Components: Two years.
      b. Expansion Tanks: One year(s).

PART 2 PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE TYPE DOMESTIC-WATER HEATERS:

A. Commercial, Gas-Fired, Storage Domestic-Water Heaters.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Raypak
      b. Or Equal
   2. Description: Storage type gas water heater with seamless glasslined steel tank construction, with foam insulation, CSA Certified, ASME rated T&P relief valve and down fired power burner.
   3. Connections: Factory fabricated of materials compatible with heater. Attach to heater before testing.
      a. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      b. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
   4. Heater Appurtenances
      a. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
      b. Jacket: Steel with enameled finish.
      c. Burner: For use with grid-type, finned-tube, gas-fired, domestic-water heaters and natural-gas fuel.
      d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, intermittent electronic-ignition system.

e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
g. With BMS interface

2.2 CAPACITY AND CHARACTERISTICS

A. Recovery: As indicated in equipment schedule at 90 deg F temperature rise.

B. Temperature Setting: 140 degrees F.

C. Fuel Gas Input: As indicated in equipment schedule.

D. Gas Pressure Regulator
1. Capacity: As indicated in equipment schedule.
2. Inlet Pressure: 0.7 inches water column.
3. Gas Pressure Required at Burner: 0.7 inches water column.

E. Electrical Characteristics
1. Volts: 120.
2. Phase: Single.
3. Hertz: 60.
4. Pump Hp: As indicated in equipment schedule.

F. Minimum Vent Diameter: As indicated in equipment schedule.

2.3 EXPANSION TANKS:

A. Description: ASME code steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following.
   a. AMTROL Inc.
   b. Or Equal
2. Construction
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
3. Capacity and Characteristics
   a. Working-Pressure Rating: 150 psig.
   b. Maximum allowable temperature: 240 degree F
   c. Capacity Acceptable: As indicated in equipment schedule.

2.4 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

C. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

D. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

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

C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Division 01 Section "Quality Requirements" for retesting and reinspecting requirements and Division 01 Section "Execution" for requirements for correcting the Work.

D. Prepare test reports.

PART 3 EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
2. Concrete base construction requirements are specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

B. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

D. Install seismic restraints for commercial water heaters. Anchor to substrate.

E. Install gas water heaters according to NFPA 54.

F. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

G. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor sink.

H. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Section 221119 – DOMESTIC WATER PIPING SPECIALTIES for hose-end drain valves.

J. Install thermometer on outlet piping of water heaters. Refer to Section 220519 – METERS AND GAUGES FOR PLUMBING PIPING for thermometers.

K. Install pressure gauges on water heater outlet piping. Refer to Section 220519 – METERS AND GAUGES FOR PLUMBING PIPING for pressure gages.

L. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Section 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING for general-duty valves and to Section 220519 – METERS AND GAUGES FOR PLUMBING PIPING for thermometers.

M. Fill water heaters with water.

N. Charge expansion tanks with air.

O. Insulate hot water storage tank.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Division 22 Section "Domestic Water Piping."

B. Comply with requirements for natural gas piping specified in Division 23 Section "Facility Natural Gas Piping."

C. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

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

E. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

F. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train the University's maintenance personnel to adjust, operate, and maintain commercial, gas fired, domestic water heaters.

END OF SECTION

SECTION 224000
PLUMBING FIXTURES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

B. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Faucets for lavatories and sinks.
   2. Laminar-flow faucet-spout outlets.
   3. Commercial sinks.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

C. Related Sections include the following:
   1. Section 224500 – EMERGENCY PLUMBING FIXTURES.
   2. Section 224700 – DRINKING FOUNTAINS AND WATER COOLERS.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

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

D. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations

1. Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
2. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

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

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
2. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
3. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
4. Faucets: ASME A112.18.1.
5. Hose-Connection Vacuum Breakers: ASSE 1011.
6. NSF Potable-Water Materials: NSF 61.
7. Pipe Threads: ASME B1.20.1.
8. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
9. Supply Fittings: ASME A112.18.1.
10. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Plastic Tubular Fittings: ASTM F 409.
4. Brass Waste Fittings: ASME A112.18.2.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Flexible Water Connectors: ASME A112.18.6.
2. Hose-Coupling Threads: ASME B1.20.7.
3. Off-Floor Fixture Supports: ASME A112.6.1M.
4. Pipe Threads: ASME B1.20.1.

1.6 LEAD FREE INSTALLATION

A. The Contractor shall install only products that comply with the requirements as described in State Assembly Bill AB-1953 for lead free products. Submit all lead free products to be installed to the University's Representative for review.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fixtures General
   1. All plumbing fixtures shall be furnished complete with all necessary trim and accessories to insure the specified installation and operation of each fixture. Trim and accessories shall include stops, supply pipes, drains, strainers, tailpieces, P-traps, escutcheons, bolt caps, hanger, carriers and supports. All exposed items and piping shall be chrome-plated.
      a. All fixture stops shall be loose key, all brass with I.P.S. threaded inlet. Threaded pipe nipple shall be I.P.S. brass or copper pipe adapter shall be sweat x M.I.P. Compression fittings are not permitted. Manufacturer shall be Chicago Faucets or equal.
      b. Supply pipe risers may be flexible plastic with steel-braided reinforcement.
      c. All traps shall be L.A. pattern cast brass adjustable ground union joint elbow and cast brass slip nuts. Trap arm extension shall be I.P.S. threaded brass nipple.
      d. Water stops, risers and trap assembly shall be insulated with pre-molded PVC covering conforming to ADA regulations. Manufacturer shall be Truebro, or equal.

B. Accessible plumbing fixtures shall comply with all the requirements of CBC Section 1115B. Heights and location of all fixtures shall be according to CBC Table 1115B-1. Fixture controls shall comply with CBC Section 1118B

2.2 SINK FAUCETS.

A. Sink Faucets, Refer to schedule on drawings.
   1. Product:
      a. Water Saver Faucet Co.
      b. Chicago Faucets.
      c. Or equal

2.3 FIXTURE SUPPORTS

A. Sink Supports
   1. Description: Type III, sink carrier with hanger plate and exposed arms for sink-type fixture. Include steel uprights with feet.

2.4 SINKS

A. Sink
   1. Product:
      a. Just
      b. Elkay
      c. Or equal
   2. Description: Single-compartment, wall-mounting.
      a. Faucet: refer to drawings
      b. Supplies: NPS 1/2 chrome-plated copper with quarter turn threaded stops, Chicago or equal.
      c. Drain Piping: NPS 2 chrome-plated, 16 gauge P-trap; 0.045-inch- thick tubular brass waste to wall; continuous waste; and wall escutcheon(s).

2.5 WATER CLOSETS.

A. Water Closets, Refer to schedule on drawings.

2.6 URINALS.

A. URINALS, Refer to schedule on drawings.

2.7 LAVATORIES.

A. Lavatories, Refer to schedule on drawings.

2.8 SHOWERS.

A. Showers, Refer to schedule on drawings.

2.9 SINKS.

A. Sinks, Refer to schedule on drawings.

PART 3 EXECUTION

3.1 EXAMINATION

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

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

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

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install wall-mounting fixtures with tubular waste piping attached to supports.

E. Install undercounter-mounting fixtures in and attached to casework.

F. Install fixtures level and plumb according to roughing-in drawings.

G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Section 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING.

H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

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

K. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

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

M. Install traps on fixture outlets.

N. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

O. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Section 079200 – JOINT SEALANTS.

3.3 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

D. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

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

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers and controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

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

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by the University’s Representative.

END OF SECTION

SECTION 224500
EMERGENCY PLUMBING FIXTURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Emergency Eyewash and Shower for non lab areas.

B. Refer to Section 222000 for emergency fixtures in lab areas.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

D. Refer to General Commissioning Requirements on Section 019113.

1.2 SUBMITTALS

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

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

C. Field quality-control test reports.

D. Operation and maintenance data.

E. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 QUALITY ASSURANCE

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

B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

D. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

PART 2 PRODUCTS

2.1 EYEWASH EQUIPMENT

A. Standard, Freestanding, Plumbed Emergency Eye Eyewash and Shower, (EEWS-1) – refer to schedule on drawing:
   1. Manufacturers: Provide Eyewash Equipment by one of the following:
      a. Bradley
      b. Guardian Equipment Co.
      c. Or equal.
   2. Capacity: Not less than 25 gpm for at least 15 minutes.

2.2 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to Owner's Representative.

PART 3 EXECUTION

3.1 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball valve type. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation, but not readily accessible. Comply with requirements for valves specified in Division 22, Section 220523 "GENERAL-DUTY VALVES FOR PLUMBING PIPING."

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Division 22, Section 221116 “PLUMBING PIPING”.

F. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations.

3.2 CONNECTIONS

A. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Division 22, Section 221116 "PLUMBING PIPING."

B. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

C. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.3 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Division 22, Section 220553 "IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT."

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION

SECTION 224700
DRINKING FOUNTAINS AND WATER COOLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

B. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. This Section includes the following drinking fountains and water coolers and related components:
   1. Drinking fountains.
   2. Fixture supports.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

1.3 DEFINITIONS

A. Accessible Drinking Fountain: Fixture that can be approached and used by people with disabilities.

B. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

C. Fitting: Device that controls flow of water into or out of fixture.

D. Fixture: Drinking fountain unless one is specifically indicated.

1.4 SUBMITTALS

A. Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Furnish submittals as required in Section 01 8113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act," for fixtures for people with disabilities.

B. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

C. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filter Cartridges: Furnish two each of the type installed.

PART 2 PRODUCTS

2.1 DRINKING FOUNTAINS

A. Drinking Fountains, Refer to schedule on drawing .
   1. Manufacturers:
      a. Oasis Corporation
      b. Haws Corporation
      c. Elkay
      d. Or equal
   2. Description: Accessible, wall-mounting drinking fountain.
      a. Material: Stainless steel.
      b. Receptor Shape: Rounded front.
      c. Back Panel: Stainless-steel wall plate behind drinking fountain.
      d. Bubblers: Two, with adjustable stream regulator, located on deck.
      e. Control: Push button.
      f. Supply: NPS 3/8 with ball valve.
      g. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
      h. Support: Type I. Refer to "Fixture Supports" Article.
      i. Refer to plumbing fixture schedule for bottle filler and chilled water requirements.

2.2 FIXTURE SUPPORTS

A. Manufacturers:
   1. Josam Co.
   2. MIFAB Manufacturing, Inc.
   3. Smith, Jay R. Mfg. Co.
   4. Tyler Pipe; Wade Div.
   5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
   6. Zurn Plumbing Products Group; Specification Drainage Operation.
   7. Or equal

B. Description: ASME A112.6.1M. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
   1. Type I: Hanger-type carrier with two vertical uprights.
   2. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

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

3.2 APPLICATIONS

A. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install in-wall plate and support legs affixed to building structure following manufacturer installation instructions.

B. Install fixtures level and plumb. For fixtures indicated for children, install at height required by 2013 California Plumbing Code & 2013 California Building Code

C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING.

D. Install waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

E. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Section 079200 – JOINT SEALERS.

3.4 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

3.5 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

3.6 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

SECTION 226113
COMPRESSED AIR PIPING FOR LABORATORY FACILITIES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Compressed-air piping and specialties for non-medical laboratory facilities, designated "laboratory air," operating at 125 psig.

B. Related Sections include the following:
   1. Division 11 Section "Laboratory Fume Hoods" for compressed-air outlets in laboratory fume hoods.
   2. Division 12 Section "Laboratory Casework" for compressed-air outlets in casework.
   3. Division 22 Section "Compressed-Air Equipment for Laboratory Facility”.

1.2 DEFINITIONS

A. D.I.S.S.: Diameter-index safety system.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Compressed-air tubes and fittings.
   2. Compressed-air valves and valve boxes.

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

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

1.4 QUALITY ASSURANCE

A. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.

B. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Gas Piping for Laboratory."

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

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

E. ASME Compliance:
   1. Comply with ASME B31.1, "Power Piping," for laboratory compressed-air piping operating at more than 150 psig.
   2. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig or less.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Copper Gas Tube: ASTM B 819, Type K, seamless, drawn temper.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint type that has been manufacturer cleaned, purged, and bagged.
   3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.2 VALVES

A. General Requirements for Valves:

B. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Nibco Inc.
   2. Beacon Medaes.
   3. Conbraco Industries, Inc.
   4. Or equal.

C. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Pressure Rating: 175 psig minimum.
   2. Ball: Full-port, chrome-plated brass.
   3. Seats: PTFE or TFE.
   4. Handle: Lever type with locking device.
   5. Stem: Blowout proof with PTFE or TFE seal.
   6. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

D. Check Valves: In-line pattern, bronze.
   1. Pressure Rating: 300 psig minimum.
   2. Operation: Spring loaded.
   3. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

E. Pressure Regulators: Bronze body and trim.
   1. Spring-loaded, diaphragm-operated, relieving type.
   2. Manual pressure-setting adjustment.
   3. Rated for 250 psig minimum inlet pressure.
   4. Capable of controlling delivered air pressure within 0.5-psig for each 10-psig inlet pressure.

2.3 COMPRESSED-AIR SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Nibco Inc.
   2. Beacon Medaes
   3. Or equal.

B. Roughing-in Assembly:
   1. Steel outlet box for recessed mounting and concealed piping.
   2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
   3. Double seals that will prevent air leakage.
   4. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.

C. Finishing Assembly:
   1. Brass housing with primary check valve.
   2. Double seals that will prevent air leakage.
   3. Cover plate with gas-service label.

D. Quick-Coupler Pressure Service Connections:

1. Outlets for instrument air with non-interchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

2.4 FLEXIBLE PIPE CONNECTORS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Metraflex, Inc.
   3. Proco Products, Inc.
   4. Or approved equal

C. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: 200 psiginimum.
   2. End Connections: Threaded copper pipe or plain-end copper tube.

2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

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

2.6 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Escutcheons: With set screw.
   1. Finish: Polished chrome-plated.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean pipe and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials.

3.2 PIPING APPLICATIONS

A. Laboratory Air Piping: Use the following piping materials for each size range:
   1. NPS 3 and Smaller: Type K, copper gas tube; wrought-copper fittings; and brazed joints.
   2. NPS 4 (DN 100) and Larger: Type K, copper gas tube; wrought-copper fittings; and brazed joints.

B. Drain Piping: Use the following piping materials:
   1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.3 PIPING INSTALLATION

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

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

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

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

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

F. Install air and drain piping with 1 percent slope downward in direction of flow.

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

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

I. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

J. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

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

N. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

O. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

P. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

Q. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

3.4 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install pressure regulators on compressed-air piping where reduced pressure is required.

D. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.

E. Install flexible pipe connectors in discharge piping[and in inlet air piping from remote air-inlet filter] of each air compressor.

3.5 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

E. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.

F. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.

3.6 SLEEVE INSTALLATION

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

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

C. Install sleeves in new walls and slabs as new walls and slabs are constructed.

D. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

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

3.7 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
    a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
    b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Bare Piping at Ceiling Penetrations in Finished Spaces.
    c. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.8 HANGER AND SUPPORT INSTALLATION

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

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

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

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

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

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

6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.
9. NPS 3: 14 feet with 1/2-inch rod.
10. NPS 3-1/2: 15 feet with 1/2-inch rod.

J. Install supports for vertical copper tubing every 10 feet (3 m).

3.9 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN NONMEDICAL LABORATORY FACILITIES

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

B. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

C. Tests and Inspections:

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

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain medical compressed-air alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 226119
COMPRESSED AIR EQUIPMENT FOR LABORATORY FACILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. Section Includes
   1. Packaged, oil-free reciprocating air compressors.
   2. Inlet-air filters.
   3. Refrigerant compressed-air dryers.

1.3 DEFINITIONS

A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.

B. Laboratory Air Equipment: Compressed-air equipment and accessories for nonmedical laboratory facilities.

C. Standard Air: Free air at 68 degrees F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   1. Wiring Diagrams: For power, signal, and control wiring.

B. Delegated-Design Submittal: For compressed-air equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of supports.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, and for designing vibration isolation bases.

C. Field quality-control reports.

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

1.6 QUALITY ASSURANCE

A. Installer Qualifications
   1. Laboratory Air System Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.
   2. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

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

C. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.7 CHECKING AND TESTING EQUIPMENT BY CONTRACTOR AND MANUFACTURER'S REPRESENTATIVE

A. Equipment shall be installed in strict accordance with manufacturer's instructions. During construction provide supervisory assistance from equipment manufacturer's representatives so the equipment will be correctly installed. After installation, request the Architect to inspect and see the equipment is in proper working order.

B. Manufacturer's shall review the overall system design relative to the proper application of his equipment in the particular system. He shall note conduit, wiring, control, location, and other relevant relationships, and furnish appurtenances necessary for satisfactory operation.

C. Before final payment is issued, the manufacturer's representative shall submit to the Architect, a signed statement certifying to their inspection and that the equipment is properly installed and ready for operation.

1.8 COORDINATION

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS

A. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 24-V ac or less, using integral control power transformer.
4. Each compressor shall be equipped with a 3.5” color touch screen for the operation of each compressor. Screen shall include run statas, hour meters, pump rotation to check pump rotation at start-up, compressor alarms, and maintenance required.
5. Motor Overload Protection: Overload relay in each phase.
6. Starting Devices: Hand-off-automatic selector panel in cover of control panel, plus pilot device for automatic control
7. Automatic control switches to alternate lead-lag air compressors for duplex air compressors.
8. Instrumentation: Include 5.7” main color touch screen discharge-air and receiver pressure gages, hour meter, dew point, trend graphs (for pressure, dew point and unit running and ambient temp) and control transformer.
9. Equipment control panel complete with BMS connection

C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gage, automatic drain, and pressure regulator.

D. Mounting Frame: Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.2 OIL-LESS, SCROLL AIR COMPRESSORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Beacon Medaes
2. Quincy Compressor; an EnPro Industries company.
3. Ingersoll-Rand; Air Solutions Group.
4. Or approved equal

C. Description: Packaged unit.

D. Air Compressor(s): Oil-less, scroll type with continous duty, single stage air-cooled compressors. The compressors have one fixed and one orbiting scroll with PTFE field replaceable tip seals.

1. Dust & contamination protection and heat dissipation by integral cooling fan.
2. Fully adjustable motor mounting base to achieve belt tensioning
3. Mounted integral air-cooled after-cooler with a maximum 15°F above ambient approach temperature with integrated draintrap and solenoid drain valve.
4. Belt guard totally enclosing pulleys and belts.
5. Discharge line includes heat shielded flex connectors.
6. Four-point heavy duty isolation system for a minimum 95% isolation efficiency fully isolates the compressor/motor tower from the system.

E. Capacities and Characteristics: As indicated on the plans.

1. Mounting: Single point connection system with vertical tank
2. Receiver: ASME construction steel tank with piped 3-valve by-pass
   a. Drain: Zero Loss Automatic valve.

2.3 INLET-AIR FILTERS

A. Description: Inlet-air filter-, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.4 DESICCANT COMPRESSED-AIR DRYERS

A. Manufacturers: Shall be provided by the same manufacturer as the air compressor system.

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. BeaconMedaes

C. Description: Duplex desiccant dryers sized for peak load and produce a 10°F pressure dew point. Each dryer operates from a demand based purge saving control system featuring repressuration cycles. Include main air system control panel operation, inlet and outlet pressure gages, 441 ceramic plated transfer valves, automatic controls, and filters.

D. Capacities and Characteristics: sized for system full load demand.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory air applications,

3.2 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation

1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install the following devices on compressed-air equipment:
    a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
    b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
    c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Nonmedical Laboratory Compressed-Air Equipment Installation

1. Install compressed-air equipment, except wall-mounting equipment[and diaphragm air compressors], on concrete bases. Install units anchored to substrate in locations indicated. Maintain manufacturers' recommended clearances. Orient equipment so controls and devices are accessible for servicing.
    a. Anchor equipment to concrete bases according to manufacturer's written instructions.
        1) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
        2) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
        3) Install anchor bolts to elevations required for proper attachment to supported equipment.
    b. Vibration Isolation: Install restrained-spring isolators with a minimum deflection of 1”. Vibration isolation devices and installation requirements are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
    c. Vibration Isolation: Mount equipment on a vibration isolation equipment base as specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

3.3 IDENTIFICATION

A. Identify nonmedical laboratory compressed-air equipment system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 STARTUP SERVICE

A. Perform startup service.

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

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air compressors, compressed-air dryers.

3.6 WARRANTY

A. Provide minimum 2 year factory warranty per district standard.

END OF SECTION

SECTION 226213
VACUUM PIPING FOR LABORATORY FACILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Laboratory high-vacuum piping and specialties, designated "laboratory high vacuum" operating at 28 inches mercury.

B. Related Sections include the following:
   1. Division 11 Section "Laboratory Fume Hoods" for vacuum outlets in laboratory fume hoods.
   2. Division 12 Section "Laboratory Casework" for vacuum outlets in casework.
   3. Division 22 Section "Vacuum Equipment for Laboratory Facilities".

C. Related Sections include the following:
   1. Division 11 Section "Laboratory Fume Hoods" for vacuum outlets in laboratory fume hoods.

1.3 DEFINITIONS

A. D.I.S.S.: Diameter-index safety system.

B. HVE: High-volume (oral) evacuation.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 SUBMITTALS

A. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Product Data: For the following:
   1. Vacuum pipes and fittings.
   2. Vacuum valves and valve boxes.

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

D. Brazing certificates.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

B. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 22 Section "Gas Piping for Laboratory's."

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

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

E. Comply with ASME B31.9, "Building Services Piping," for vacuum piping in laboratory facilities.

PART 2 PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Copper Gas Tube: ASTM B 819, Type K, seamless, drawn temper.

B. Wrought-Copper Fittings: ASME B16.22, solder-joint type that has been manufacturer cleaned, purged, and sealed for gas service

C. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

2.2 FLEXIBLE PIPE CONNECTORS

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

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

1. Flex-Hose Co., Inc.
2. Metraflex, Inc.
3. Proco Products, Inc.
4. Or approved equal.

C. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: 200 psig minimum.
2. End Connections: Threaded copper pipe or plain-end copper tube.

2.3 JOINING MATERIALS

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

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

2.4 VALVES

A. General Requirements for Valves

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

1. Nibco Inc.
2. Beacon Medaes.
3. Conbraco Industries, Inc.
4. Or approved equal.

C. Copper-Alloy Ball Valves:

1. Standard: MSS SP-110.
2. Description: Three-piece body, brass or bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Ball: Full-port, chrome-plated brass.
5. Seats: PTFE or TFE.
6. Handle: Lever type with locking device.
7. Stem: Blowout proof with PTFE or TFE seal.
8. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

D. Check Valves:

1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

2.5 VACUUM SERVICE CONNECTIONS

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

1. Nibco Inc.
2. BeaconMedaes.
3. Or approved equal.

B. General Requirements for Vacuum Service Connections:

1. Suitable for specific vacuum service listed.
2. Include roughing-in assemblies, finishing assemblies, and cover plates.
3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
4. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:

1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body inlet block.
3. Seals that will prevent vacuum leakage.
4. ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:

1. Brass housing with primary check valve.
2. Seals that will prevent vacuum leakage.
3. Cover plate with gas-service label.

E. Quick-Coupler Suction Service Connections:

1. Inlets for vacuum with non-interchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

F. Cover Plates:

1. One piece.
2. Aluminum.
3. Permanent, color-coded, identifying label matching corresponding service.

2.6 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

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

1. Underdeck Clamp: Clamping ring with set screws.

2.7 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Escutcheons: With set screw.

D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.

E. One-Piece, Floor-Plate Escutcheons: Cast iron.

F. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean pipe and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials.

3.2 PIPING APPLICATIONS

A. Connect new copper tubing to existing tubing with memory-metal couplings.

B. Laboratory High Vacuum Piping: Use the following piping materials for each size range:
   1. NPS 3 and Smaller: Type K, copper gas tube; wrought-copper fittings; and brazed joints.
   2. NPS 4 (DN 100) and Larger: Type K, copper gas tube; wrought-copper fittings; and brazed joints.

C. Drain Piping: Use the following piping materials:
   1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.3 PIPING INSTALLATION

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

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

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

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

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

F. Install vacuum and drain piping with 1 percent slope downward in direction of flow.

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

H. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

I. Provide drain leg and drain trap at end of each main and branch and at low points.

J. Install piping to permit valve servicing.

K. Install piping free of sags and bends.

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

M. Install vacuum piping to medical vacuum service connections specified in this Section and to equipment specified in other Sections requiring medical vacuum service.

N. Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

O. Install vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

P. Install vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

Q. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

R. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

3.4 VALVE APPLICATIONS

A. Valves for Copper Vacuum Tubing: Use copper alloy ball and bronze check types.

3.5 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain, so contents spill over or into it.

D. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.6 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

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

D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

G. Extruded-Tee Outlets: Form branches in copper tube according to ASTM F 2014, with tools recommended by procedure manufacture.

3.7 SLEEVE INSTALLATION

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

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

C. Install sleeves in new walls and slabs as new walls and slabs are constructed.

D. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

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

3.8 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
4. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.9 HANGER AND SUPPORT INSTALLATION

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

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

C. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   3. NPS 3/4: 84 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   5. NPS 1-1/4: 108 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.
   8. NPS 2-1/2: 13 feet with 1/2-inch rod.
   9. NPS 3: 14 feet with 1/2-inch rod.
   10. NPS 3-1/2: 15 feet with 1/2-inch rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

3.10 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.11 FIELD QUALITY CONTROL FOR LABORATORY FACILITY NONMEDICAL VACUUM PIPING

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of vacuum piping in nonmedical laboratory facilities.

B. Perform tests and inspections of vacuum piping in nonmedical laboratory facilities.

C. Tests and Inspections:
   1. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
      a. Test Pressure for Copper Tubing: 150 psig.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect filters for proper operation.

D. Prepare test reports.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain medical vacuum alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 226219
VACUUM EQUIPMENT FOR LABORATORY FACILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. Section Includes
   1. Packaged, reciprocating vacuum pumps.

1.3 DEFINITIONS

A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in expanded cfm.

B. Laboratory Vacuum Equipment: Equipment and accessories for nonmedical laboratory facilities.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Standard Air: Free air at 68 degrees F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vacuum equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Seismic Performance: Vacuum equipment shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   1. Wiring Diagrams: For power, signal, and control wiring.

B. Delegated-Design Submittal: For vacuum-producing equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of supports.
   2. Design Calculations: Calculate requirements for selecting vibration isolators[and seismic restraints] and for designing vibration isolation bases.

C. Seismic Qualification Certificates: For vacuum producers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

E. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Laboratory Vacuum System Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated, that is an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

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

D. ASME Compliance: Fabricate and label receivers and separators to comply with ASME Boiler and Pressure Vessel Code.

1.7 COORDINATION

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PACKAGED VACUUM PUMPS

A. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.

B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
   1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
   2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
   3. Control Voltage: 120-V ac or less, using integral control power transformer.
   4. Motor Overload Protection: Overload relay in each phase.
   5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   6. Automatic control switches to [alternate lead-lag vacuum pumps for duplex] [and] [sequence lead-lag vacuum pumps for multiplex] vacuum pumps.
   7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, and control transformer.
   8. Control Panel connected to BMS.

C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
   1. Interior Finish: steel
   2. Accessories: Include vacuum relief valve, vacuum gage, and manual drain.

D. Mounting Frame: Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.2 OIL-SEALED LIQUID RING VACUUM PUMPS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide Ingersoll-Rand, or comparable product by one of the following:

1. Ingersoll-Rand; Air Solutions Group.
2. Dekker Vacuum Technologies
3. Or approved equal.

C. Description: Packaged unit.

D. Vacuum Pump(s): Oil-Sealed, Liquid Ring type.
   1. Inlet filters.
   2. Low-lubrication oil level switches,
   3. air-cooled
   4. Drive drive pump/motor
   5. Outlet DX-5 separator and oil-mist element on discharge piping.

E. Capacities and Characteristics:
   1. Vacuum Service: Laboratory vacuum.
   2. Vacuum Pump(s): Triplex.
   3. Capacities and performance as indicated on the plans.
   4. Receiver: ASME construction steel tank with vacuum relief valve.
      a. Orientation: Vertical.
      b. Drain: manual.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 COMPUTER INTERFACE CABINET

A. Description:
   1. Wall mounting.
   2. Welded steel with white-enamel finish.
   3. Gasketed door.
   4. Grounding device.
   5. Factory-installed signal circuit boards.
   6. Power transformer.
   7. Circuit breaker.
   8. Wiring terminal board.
   9. Internal wiring capable of interfacing 20 alarm signals.

PART 3 EXECUTION

3.1 PREPARATION

A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

A. Equipment Mounting: Install vacuum producers on concrete bases using restrained spring isolators. Comply with requirements in Division 03 Section. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   1. Minimum Deflection: (6 mm)1 inch. (25 mm)

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install vacuum producers restrained spring isolators. Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. Minimum Deflection: (6 mm)1 inch. (25 mm)

C. Equipment Mounting: Install vacuum producers on vibration isolation inertia bases. Comply with requirements specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Equipment Mounting: Install vacuum producers on concrete bases. Comply with requirements in Division 03 Section.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Install vacuum equipment anchored to substrate.

F. Orient equipment so controls and devices are accessible for servicing.

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

H. Install the following devices on vacuum equipment:

1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.
2. Drain Valves: Install on receivers and separators. Discharge receiver condensate over nearest floor drain. Discharge separator oral evacuation fluids by direct connection into sanitary waste piping system.

3.3 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that vacuum producer outlet piping is clear.
5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings.
7. Check for proper seismic restraints.
8. Drain receiver and separator tank.
9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.

B. Verify that vacuum equipment is installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in Division 26 Sections.

D. Prepare written report documenting testing procedures and results.

3.4 DEMONSTRATION

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

END OF SECTION

SECTION 226600
CHEMICAL WASTE SYSTEMS FOR LABORATORY FACILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes
   1. Single-wall piping.
   2. Piping specialties.
   3. Sampling tank.
   4. Manholes.

1.3 DEFINITIONS

A. PP: Polypropylene.

1.4 PERFORMANCE REQUIREMENTS

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

B. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.5 SUBMITTALS

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

B. Shop Drawings: For neutralization system and leak-detection system. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail neutralization-system assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Detail leak-detection-system assemblies and indicate required clearances, method of field assembly, components, and location and size of each field connection.
   3. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

E. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.

F. Field quality-control test reports.

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

1.6 QUALITY ASSURANCE

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

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

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

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

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

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

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

PART 2 PRODUCTS

2.1 SINGLE-WALL PIPE AND FITTINGS

A. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion- and mechanical joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
   b. Sloane, George Fischer Inc.

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

2.2 JOINING MATERIALS

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

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

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

D. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

E. Fiberglass-Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.3 PIPING SPECIALTIES

A. High-Silicon-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following that may be incorporated into the Work include, but are not limited to, the following:
   a. Flowserve Corporation; Foundry Operations.

2. Standard: ASTM A 861, fitting with PTFE gasket and closure plug, of design appropriate for piping application.

2.4 SAMPLING TANK

A. Sampling Tank: Refer to schedule on drawings. With removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.

1. pH probe: Type and length suitable for sampling-tank size.

2.5 SLEEVES

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

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

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

2.6 SLEEVE SEALS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings, or a comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

C. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Pressure Plates: Carbon steel.
2. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.7 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Stamped-Steel Escutcheons: With set screw and chrome-plated finish.

D. Split-Plate, Stamped-Steel Escutcheons: With concealed and chrome-plated finish.

E. One-Piece, Floor-Plate Escutcheons: Cast iron.

F. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.1 EARTHWORK

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

3.2 CONCRETE BASES

A. Anchor neutralization tank and sampling tank to concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch centers around full perimeter of base.
2. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
6. Use 3000-ps), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete and “Miscellaneous Cast-in-Place Concrete."

B. Comply with requirements in Division 03 for cast-in-place concrete materials and placement.

3.3 PIPING INSTALLATION

A. Chemical-Waste Sewerage Outside the Building:

1. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
5. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
6. Install drainage piping pitched down in direction of flow, at minimum slope,unless otherwise indicated.
7. Install drainage piping with 36-inch minimum cover.
8. Install field-fabrication containment piping over new and existing carrier piping. Use containment piping manufacturer's fastening system.
9. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

B. Chemical-Waste Piping Inside the Building:

1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.

10. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
    a. Piping:
        1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
        2) Insulated Piping: One-piece, stamped-steel type with spring clips.
        3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
        4) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
        5) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw.
        6) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
        7) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
11. Sleeves are not required for core-drilled holes.
12. Permanent sleeves are not required for holes formed by removable PE sleeves.
13. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
14. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
    a. Cut sleeves to length for mounting flush with both surfaces.
        1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
    b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
    c. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
        1) Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
        2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
        3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
        4) Seal space outside of sleeve fittings with grout.
    d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
15. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Install steel pipe for sleeves smaller than 6 inches in diameter.
    b. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
    c. Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
16. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
17. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
18. Verify final equipment locations for roughing-in.

3.4 PIPING SPECIALTY INSTALLATION

A. Embed floor drains in 4-inch (100-mm) minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section "Cast-in-Place Concrete', or "Miscellaneous Cast-in-Place Concrete" for concrete.

B. Fasten grates to drains if indicated.

C. Set floor drains with tops flush with pavement surface.

D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.5 JOINT CONSTRUCTION

A. Chemical-Waste Sewerage Outside the Building:

1. Plastic-Piping, Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
2. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.

B. Chemical-Waste Piping Inside the Building:

1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping[and carrier piping of containment piping].

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

C. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

D. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting and coupling.

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

G. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch (10 mm).

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

1. NPS 2 (DN 50): 33 inches (840 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.

I. Install supports for vertical PP piping every 72 inches (1830 mm).

J. Support piping and tubing not listed above according to MSS SP-69.

3.7 CONCRETE PLACEMENT

A. Comply with requirements in Division 03 Section "Cast-in-Place Concrete", or "Miscellaneous Cast-in-Place Concrete" for concrete supports.

B. Place cast-in-place concrete according to ACI 318/318R.

3.8 CONNECTIONS

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

B. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.

C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi. (20.7 MPa)

D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

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

3.9 LABELING AND IDENTIFICATION

A. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
   1. Use warning tape or detectable warning tape over ferrous piping.
   2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.10 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.
   1. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Hydrostatic Tests for Drainage Piping:
         1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer) of pipe, during 24-hour period.
         2) Close openings in system and fill with water.
         3) Purge air and refill with water.
         4) Disconnect water supply.
         5) Test and inspect joints for leaks.
      e. Air Tests for Drainage Piping: Comply with UNI-B-6.
   2. Leaks and loss in test pressure constitute defects that must be repaired.
   3. Submit separate reports for each test.

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

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

D. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled neutralization systems and their installation, including piping and electrical connections, and to assist in testing.

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

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

G. Prepare test and inspection reports.

3.11 STARTUP SERVICE

A. Perform startup service for neutralization systems.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Neutralization Systems:
   a. Verify that neutralization system is installed and connected according to the Contract Documents.
   b. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
   c. Install neutralizing solutions and limestone.
   d. Energize circuits.
   e. Start and run systems through complete sequence of operations.
   f. Adjust operating controls.

3.12 CLEANING

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

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

3.13 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems.

3.14 PIPING SCHEDULE

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

B. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:

1. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PE drainage pipe and fittings and heat-fusion joints.
2. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PP drainage pipe and fittings and electrofusion joints.
3. NPS 6 (DN 150): PP drainage pipe and fittings and electrofusion joints.

C. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion joints.

D. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion joints.

END OF SECTION

SECTION 226700
PROCESSED WATER SYSTEMS AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to General Commissioning Requirements on Section 019113.

1.2 SUMMARY

A. Section includes reverse-osmosis-water piping & equipment.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure Ratings
   1. Reverse-Osmosis-Water Piping: 100 psig unless otherwise indicated.

B. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 ACTION SUBMITTALS

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

B. LEED Submittals
   1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.3, "Process Piping," for piping conveying fluid at a pressure of 15 psig or greater.

C. The RO-DI water system shall be installed by a quality water purification contractor.

PART 2 PRODUCTS

2.1 PLASTIC PIPE AND FITTINGS

A. PP Pipe and Fittings for Heat-Fusion Joints: Made from ASTM D 4101, PP resin.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. George Fischer LLC.
      b. IPEX Inc.
      c. Orion Fittings; a division of Watts Water Technologies Inc.
      d. Or approved equal
   2. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

2.2 TRANSITION FITTINGS

A. Transition Fittings: Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 PP VALVES

A. PP Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. George Fischer LLC.
      b. IPEX Inc.
      c. Orion Fittings; a division of Watts Water Technologies Inc.
      d. Or approved equal
   2. Description:
      a. Standard: MSS SP-122.
      b. Pressure Rating: 150 psig at 73 degrees F.
      c. Body Material: ASTM D 4101, PP resin.
      d. Body Design: Union type.
      e. End Connections: Detachable, butt or socket.
      f. Ball: ASTM D 4101, PP resin.
      g. Port: Full.
      h. Seats: PTFE.
      i. Stem: ASTM D 4101, PP resin.
      j. Stem Seals: FKM-rubber O-rings.
      k. Handle: Tee shaped.

B. PP Ball-Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. George Fischer LLC.
      b. IPEX Inc.
      c. Orion Fittings; a division of Watts Water Technologies Inc.
      d. Or approved equal.
   2. Description:
      a. Pressure Rating: 150 psig at 73 degrees F.
      b. Body Material: ASTM D 4101, PP resin.
      c. Body Design: Union type.
      d. End Connections: Detachable, socket.
      e. Ball: ASTM D 4101, PP resin.
      f. Seat and Seals: FKM-rubber O-rings.

C. PP Swing-Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.

b. Asahi/America.
c. Hayward Flow Control Systems.
d. Spears Manufacturing Company.
e. Thermoplastic Valves, Inc.
f. Or approved equal.

2. Description:
   a. Pressure Rating: 150 psig at 73 degrees F.
   b. Body Material: ASTM D 4101, PP resin.
   c. Body Design: Bolted-bonnet type.
   d. End Connections: Flanged.
   e. Shaft: ASTM D 4101, PP resin.
   f. Disc and Arm: ASTM D 4101, PP resin.
   g. Gasket and Seals: FKM rubber.

2.4 WATER SOFTENER SYSTEM

A. The system shall be capable of producing soft water for the industrial hot water system as well as pre-treatment for the RO-DI system.

B. Refer to drawings for details.

2.5 REVERSE OSMOSIS SYSTEM

A. The system shall be capable of producing 28 gallons per minute of ASTM II water.

B. Refer to drawings for details.

PART 3 EXECUTION

3.1 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

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

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

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

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

G. Install piping to permit valve servicing.

H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.

I. Install piping free of sags and bends.

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

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. PP Piping Heat-Fusion Joints: Make according to ASTM D 2657.

C. Stainless-Steel Sanitary Tubing Joints: Make fully penetrated-wall, butt-welding joints without use of filler metal. Comply with AWS D1.6/D1.6M for welding procedures and processes. Polish exterior of welds to match tubing.

D. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 VALVE INSTALLATION

A. Install sectional valves close to mains on each branch and riser serving equipment.

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

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

D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.

E. Install plastic valves of the same material as the plastic pipe in which they are installed.

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

G. Install valves in position to allow full movement of stem and lever handle.

H. Install ball-check valves in horizontal or vertical position so ball will unseat during normal flow.

I. Install swing-check valves in horizontal position with the hinge pin level.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Clamps for Vertical Piping: MSS Type 8 or Type 42.
6. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs, 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

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

E. Rod diameter may be reduced one size for double-rod hangers, to minimum 3/8 inch.

F. Install padded hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 and NPS 3: 48 inches with 1/2-inch rod.

G. Install padded supports for vertical PP piping NPS 2-1/2 and larger every 120 inches and midstory for NPS 2 and smaller.

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

3.5 CONNECTIONS

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

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

C. Connect reverse-osmosis-water piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. Test new piping, and parts of existing piping that have been altered, extended, or repaired, for leaks and defects.

1. Schedule tests and their inspections by Owner, with at least 24 hours' advance notice.
2. Do not cover piping or put into service before inspection and approval.
3. Test completed piping according to authorities having jurisdiction. If authorities having jurisdiction do not have published procedures, perform tests as follows:
    a. Hydrostatic Tests: Test piping at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 100 psig. Do not subject glass piping to pressure above manufacturer's pressure rating for size.
4. Replace leaking joints with new materials and retest until no leaks exist.
5. Submit separate reports for each test.

3.8 CLEANING

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

1. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
2. Clean piping by flushing with reverse-osmosis water.

3.9 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.

B. RO-DI-Water Piping (Supply and Return Piping): Use any of the following piping materials for each pipe size range:

1. NPS 3 and Smaller: PP pipe and fittings and heat-fusion joints.

3.10 VALVE SCHEDULE

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

1. Shutoff Duty: Install ball valves in piping NPS 2 and smaller. Install butterfly or diaphragm valves for NPS 3 piping.
2. Throttling Duty: Install ball valves in piping NPS 2 and smaller. Install diaphragm valves for NPS 3 piping.

END OF SECTION

SECTION 230000
BASIC MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes information on the general requirements for work completed under Division 23.

B. Related Sections include the following:
   1. Section 230500 – COMMON WORK RESULTS FOR HVAC.
   2. Section 233113 – METAL DUCTS.
   3. Section 015719 – CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT.
   4. Section 019113 – COMMISSIONING REQUIREMENTS.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DESCRIPTION OF WORK

A. The requirements of this Section apply to all Work of Division 23.

B. Provide a complete working installation with equipment called for in operational condition. Documents do not undertake to show or list every item to be provided. Provide items necessary for the complete operation of equipment and systems.

C. The scope of work shall include but shall not be limited to the following:
   1. Provide and install air-handling units; supply, exhaust and relief fans, packaged unit, VRF system air conditioning units, supply and exhaust air valves and air terminal units.
   2. Provide and install heating hot water central plant complete with boilers, pumps, expansion tanks, air separator, chemical pot feeder and accessories.
   3. Provide and install ductwork and air distribution devices to complete the HVAC supply, return, relief, make-up, outside and exhaust air systems.
   4. Provide and install water heater and boiler flue vent system complete with terminal exhaust fans.
   5. Provide and install heating hot water piping system that delivers heating hot water to supply air valves and air terminal unit heating coils complete with valving, supports and accessories.
   6. Provide and install refrigerant piping and accessories for the VRF system.
   7. Provide and install chilled water piping system to air handling units and chilled water fan coils complete with valving, supports and accessories, to 5 feet outside the building and connection to the campus utility distribution.
   8. Provide and install complete building management control system for air and water systems to match Campus standard.
   9. Provide and install seismic bracing and isolation necessary for HVAC equipment, piping and ductwork. Provide drawings and calculations stamped and signed by a structural engineer registered in the State of California.
   10. Provide testing, adjusting and balancing (TAB) for air and hydronic systems.

1.3 QUALITY ASSURANCE

A. Reference to technical societies, trade organizations, governmental agencies is made in this Division in accordance with the following abbreviations:
   1. AABC Associated Air Balance Council
   2. AGA American Gas Association
   3. AMCA Air Moving and Conditioning Association
   4. ANSI American National Standards Institute
   5. ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers

6. ASME American Society Mechanical Engineers
7. ASPE American society of Plumbing Engineers
8. ASSE American Society of Sanitary Engineering
9. ASTM American Society for Testing and Materials
10. AWWA American Water Works Association
11. CBC California Building Code
12. CCR California Code of Regulations
13. CEC California Electrical Code
14. CISPI Cast Iron Soil Pipe Institute
15. CMC California Mechanical Code
16. CPC California Plumbing Code
17. EPA Environmental Protection Agency
18. IAPMO International Association of Plumbing and Mechanical Officials
19. IEEE Institute of Electrical and Electronics Engineers
20. NEMA National Electrical Manufacturers' Association
21. NFPA National Fire Protection Association
22. OSHA Occupational Safety and Health Administration
23. SMACNA Sheet Metal and Air Conditioning Contractors National Association
24. UL Underwriters Laboratories, Inc.

B. Install work by craftsmen with minimum 10 years experience in the trade involved and by apprentices as indicated in the General Conditions.

C. Electrical Testing: Obtain the services of a qualified testing laboratory / agency to perform the specified field tests. Notify the Owner’s Representative 24 hours in advance of performance of Work requiring testing. Provide materials required for testing. Refer to Division 26 for detailed requirements.

D. Factory and Field Testing
   1. See each section for the required testing and their procedures.
   2. Test reports shall include:
      a. Description of equipment tested.
      b. Description of test procedures.
      c. Test results.
      d. Names and signatures of witnesses of tests.

1.4 MATERIALS AND WORKMANSHIP

A. Contractor to provide fittings, transitions, dampers, valves and other devices required for a complete workable installation. Manufacturer’s installation instructions shall be made available to the Owner’s Representative.

B. Materials and adhesives used throughout the mechanical and plumbing systems shall have a flame spread rating not over 25 without evidence of continued combustion and with a smoke developed rating not higher than 50. If such materials are to be applied with adhesives and the adhesives used shall have a flame spread rating not over 25 and a smoke developed rating not higher than 50. “Flame Spread Rating" and "Smoke Developed Rating" shall be as determined by the "method of test of surface burning characteristics of building materials, NFPA No. 244, ASTM E84, Underwriters Laboratories, Inc., Standard". Such materials are listed in the Underwriters Laboratories, Inc., "Building Materials List" under the heading "Hazard Classification (Fire)".

1.5 TESTING EQUIPMENT BY CONTRACTORS AND MANUFACTURER’S REPRESENTATIVE

A. Equipment shall be installed in accordance with manufacturer's instructions. During construction request supervisory assistance from equipment manufacturer's representatives so the equipment will be correctly installed.

B. Have the manufacturer shall review the overall system design relative to the proper application of his equipment in the particular system. Have him/her note conduit, wiring, control, location, and other relevant relationships, and furnish appurtenances necessary for satisfactory operation.

C. Prior to final acceptance of work, submit to the Owner’s Representative a signed statement by the manufacturer certifying to their inspection and the equipment is properly installed and ready for operation. Necessary permits shall have been obtained by the Contractor and submitted to and approved by the Owner’s Representative.

1.6 LIST OF MATERIALS AND EQUIPMENT

A. Submit a List of Materials and Equipment in accordance with procedure in Division 1 to the Owner’s Representative for approval of manufacturers of all materials and equipment proposed to be provided for this project.

B. The approval of the List of Material and Equipment shall be subject to submission and review of shop drawings.

1.7 SHOP DRAWINGS, SUBMITTALS

A. Submit as a minimum where applicable the following for all equipment for review. See individual sections for more requirements.

1. Manufacturer's drawings and performance data on all equipment.
2. Dimensioned drawings showing required openings.
3. Dimensioned drawings of equipment rooms, including exact equipment locations.
4. Dimensioned ductwork and piping installation drawings complete with elevations and fittings (1/4" = 1'-0" scale), or larger.
5. Equipment wiring diagrams.
6. Field installation diagrams.
7. Controls diagrams including diagrams and layout, software packages and control wiring diagrams.
8. "As-Built" drawings.

B. Conform to the following:

1. Submit complete submittals only.
2. Submit pertinent catalog and performance data sheets only.
3. Mark the exact equipment item and data on each sheet.
4. Contractor shall not submit entire catalogs.
5. Diagrams and drawings shall be submitted on sepia transparencies with required number of prints.

C. The Contractor shall prepare and furnish fully coordinated shop drawings showing ductwork and piping on separate drawings. The drawings shall be minimum 1/4" = 1'-0" scale and shall show dimensioning of piping and ductwork from gridlines, bottom of elevation marks for ductwork and piping and fittings, valves, dampers, devices, etc. with labels. In addition, the Contractor shall coordinate work specified in other sections. Any conflicts which occur shall be brought to the attention of the Owner’s Representative prior to issuance of the Drawings. Refer to Division 01 of the Specifications for additional requirements.

D. When shop drawings are in the form of custom-prepared drawings, schedules or modified printed literature, they shall be prepared using an approved CAD (Computer Aided Drafting) system.

E. Shop drawings shall be required for all equipment and devices which are provided.

F. Submission shall be made in the form of a tab-indexed brochure. Index sheets shall be required for all material, including pipe, valves, insulation, conduit and wire as listed. Each submission shall be made under the Specifications Section Number it has been specified under.

G. Each group of material shall be submitted in tabulated form.

H. Incomplete submittals and submittals not in accordance with the above requirements shall be returned without action, and re-submittal shall be required.

I. Any corrections or modifications made by the Owner’s Representative shall be deemed acceptable to the Contractor with no change in contract amount unless written notice complying with requirements specified in the General Conditions is received by the Owner’s Representative prior to the performance of any work affected by any corrections or modifications.

J. No material or equipment shall be released for manufacture or shipment without first obtaining the Owner’s Representative approved shop drawings.

K. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 01 8113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.8 SUBSTITUTIONS

A. Refer to Section 012513, PRODUCT SUBSTITUTION PROCEDURES.

B. Submit shop drawings and proposed products that differ from the scheduled or first named products and also indicate products with connections and show arrangements. Show necessary modifications of Architectural, structural, plumbing, fire protection, electrical and mechanical work required by the proposed products, including relocation of drains, revised electrical circuits, relocation of roof or wall penetrations, and revised foundations.

C. Accompany request for substitution review by table of comparison listing pertinent features of both first named and proposed materials including material of construction, overall length, width, height dimensions, space required for maintenance access, motor type, horsepower, voltage, phase service factor and noise levels. Review of proposed substitution will not be made until receipt of satisfactory comparison tabulation.

D. Limit submittal of substitutions to one proposal for each type or kind of items, unless otherwise permitted by the Owner. Substitution shall be limited to one per product, if first proposed product submittal is rejected, submit the first-named or scheduled product.

E. Review of drawings and other material submitted shall not be construed as a complete check or constitute a waiver of the requirements of the Contract Documents. This review shall not relieve the Contractor of the responsibility to fit the proposed materials to the spaces provided, and to effect necessary rearrangement or construction of other Work.

F. Any additional work required by other trades as a result of a substitution shall be covered under this Contract.

G. When a substitution is proposed, the Contractor shall be responsible to ensure that the performance and quality of the scheduled or specified equipment is met whether it requires additional accessories or not.

1.9 SHOP DRAWINGS, CHECKING

A. Before submitting shop drawings of equipment to the Owner’s Representative, check them in detail to be sure that all requirements of the plans and specifications have been fully met. Review by the Owner’s Representative of Shop Drawings does not release the Contractor from full compliance with the requirements of the plans and specifications when Shop Drawings deviate from these requirements.

B. Even though Shop Drawings have been stamped "Reviewed" and no exceptions have been taken by the Owner’s Representative, the Contractor shall be fully responsible for all unauthorized deviations from the plans and specifications. Authorization for deviation will be made only by means of a letter from the Owner’s Representative. The Owner’s Representative's reviewed "No Exceptions Taken" stamp on a Shop Drawing is not an authorization for a deviation from the plans and specifications.

1.10 REGULATIONS AND CODES

A. Conform to all applicable code requirements.

B. Obtain the required permits from the local authorities for this work and pay for all fees required by the local, State, and Federal authorities for permits, inspections and review, including special agency construction and operating permits. Make corrections in the work as required by the Owner’s Representative or Inspector to pass local regulations.

C. Provide Owner, Owner’s Representative and local Inspectors access to work at all times.

D. Contractor shall be responsible for all law violations caused by the work under this Division. Notify Owner's Representative in writing when a discrepancy occurs between code requirements and work shown on drawings and resolve matter before proceeding with work.

E. Make application and pay for all certificates of inspection, taxes and permits required by Local, State or Federal Governments, public utilities, or other authorities having lawful jurisdiction. Deliver to the Owner's Representative any and all certificates of inspections, permits, and approvals which may be required by such authorities.

F. Refer to 014100 REGULATORY REQUIREMENTS.

1.11 COORDINATION OF ALL WORK

A. In accordance with General Conditions Paragraph 3.2, coordinate all work as necessary to achieve a complete neatly fitted installation for each condition. Consult the Drawings and Specifications to determine nature and extent of work specified in other Divisions which adjoins or attaches to the work of this Division. Confer with other Divisions at the site to coordinate this work with theirs in view of job conditions to the end that interferences may be eliminated and that maximum head room and clearance may be obtained. No additional compensation will be allowed for the moving of piping, ductwork, conduit or equipment to clear such interferences.

1.12 DRAWINGS

A. The drawings show the general arrangement of all piping, ductwork, conduit and equipment. Examine drawings and specifications very carefully, and notify the Owner's Representative by letter of any discrepancies so same can be rectified at an early date and prior to installation.

B. Should conditions necessitate any rearrangements, the Contractor shall prepare and submit drawings showing the changes before proceeding with the work. If such changes are approved, they shall become a part of this contract after their approval.

C. Due to the small scale of the drawings, it is not possible to show all offsets and every detail of construction. Additional fittings, valves, traps, vacuum breakers, ducts, etc. to complete the installation, shall be furnished and installed at no extra cost to the Owner.

D. The drawings are diagrammatic and are a graphic representation of the Contract Requirements, produced according to the best available standards to an optimum scale. Dimensions of work as indicated on plans are not guaranteed to be as-built dimensions. No measurements shall be scaled from the Drawings and used as a definite dimension for layout or fitting work in place.

E. The layout of equipment, as shown on the plans, shall be checked and exact location determined by dimensions of equipment accepted for installation. Consult the architectural and Structural Drawings for all dimensions, locations of partitions, sizes of structural members, foundations, etc.

F. The Contractor shall be responsible for the coordination of the mechanical ducting and piping distribution with the fire sprinklers, lighting, conduit, cable tray and structural members.

G. Duct dimensions shown on the drawings indicate the net inside clear dimension exclusive of any internal insulation or lining. All pipe sizes are nominal diameters.

1.13 LOCAL CONDITIONS

A. Prior to bidding visit the site and determine all existing conditions affecting work in this Division. Examine all Drawings and Specifications to familiarize with the type of construction to be used, and the nature and extent of work of other trades.

B. Observe the conditions under which deliveries of materials and equipment shall be made and under which such materials and equipment can be stored, and shall include adequate provision therefore in this proposal.

C. The location and elevation of the underground utilities, such as sewers, electrical power, water piping, conduit, etc., is as exact as can be determined from available information and its accuracy cannot be guaranteed. Exact location and elevation of these services shall be verified prior to excavation or installation of any portion of the work indicated. Exercise special care when excavating at or near the general location of underground utilities to avoid damage to the utility services, as well as to insure worker safety.

D. Any connections to or relocation of any existing utility line requiring temporary discontinuance of utility services which are in active use shall be scheduled and coordinated with the utility companies and the Owner's Representative. In no case shall the services be left disconnected at the end of a working day or weekend unless authorized by representatives of the utilities and the Owner. Any existing utility service damaged shall be repaired to the satisfaction of the Owner's Representative.

1.14 PROVISIONS FOR LATER INSTALLATIONS

A. Where any mechanical work cannot be installed as the work progresses, Contractor shall provide and arrange for the building in of boxes, sleeves, inserts, fixtures or devices as necessary to permit installation of the omitted work during later phases of construction. Arrange for and lay out any chases, holes, or other openings which must be provided in masonry, concrete or other work.

1.15 MINOR DEVIATION

A. The dimensions and ratings of equipment herein specified or indicated on the Drawings are intended to establish the desired outlines and characteristics of such equipment. Minor deviations may be permitted after review by the Owner's Representative to allow manufacturers specified to bid on their nearest standard equipment.

B. Manufacturers catalog or model numbers and types mentioned in the Specifications or indicated on the drawings are intended to be used as guides and shall not be interpreted as taking precedence over specific ratings or duty called for or shown, which modify stipulations in such catalogs. In all cases, verify the duty specified with the particular characteristics of the equipment, and submit only items which comply with specification requirements.

1.16 HOIST, RIGGING, TRANSPORTATION AND SCAFFOLDING

A. Provide all scaffolding, staging, cribbing, tackle hoist and rigging necessary for placing all materials and equipment in their proper places in the project. All temporary work shall be removed from the premises when its use is no longer required.

1.17 CUTTING AND PATCHING

A. Refer to Section 017219, CUTTING AND PATCHING.

1.18 PROTECTION

A. Refer to General Conditions Paragraph 10.2 and Section 016000, PRODUCT REQUIREMENTS.

1.19 FIELD VERIFICATION

A. Architectural plans will hold precedence over mechanical and electrical plans as to location of partitions, etc.

B. All roughing in construction dimensions shall be made from Architectural plans where discrepancies may exist.

1.20 ROOF OPENINGS AND CURBS

A. Roof Curbs: Prefabricated roof curbs shall be of the standard or sound attenuating type and shall be a minimum 12 inches high above finished roof surface.

B. Flashing and Counterflashing

1. Flashing around roof curbs shall be as detailed on the drawings. Counter-flashing shall be required on curbed openings and shall be 16 ounce CRC, except where counter-flashing is a component part of equipment (such as roof exhausters).

2. Openings passing through roof shall be made watertight by means of RPS, Pate Corp. or equal roof curbs and acrylic-coated ABS rib-reinforced plastic curb cover and EPDM protection rubber caps, complete with stainless steel, snap-lock swivel clamps.

1.21 ROOFTOP PIPE, DUCT AND EQUIPMENT SUPPORTS

A. Provide leak-proof equipment supports for roof mounted equipment, (except equipment specified to be supplied with integral or matching curb).

B. Supports shall be prefabricated of continuous welded 18 gauge minimum galvanized steel, 12 inches minimum height, mitered corner seams, integral cant and base plate, 2-inch by 4-inch fire resistant treated wood nailer, or 18 gauge counterflashing. Provide integral internal reinforcing necessary to support imposed load, but no less than 600 pounds per linear foot of perimeter.

C. Top surface shall be level. Provide base or special curbs where installed on pitched roof.

D. Install all roof piping and ductwork on supports as manufactured by Pate, Stiles or equal.

E. Pitch pans and pitch pockets shall not be allowed.

1.22 TOOLS AND EQUIPMENT

A. Furnish all tools and equipment necessary for the proper installation, protection and upkeep of the work.

1.23 EXPANSION AND CONTRACTION

A. Take all necessary precautions required to care for the contraction and expansion of all piping.

B. All piping shall be properly supported, guided, aligned and anchored for expansion and contraction.

C. Provide expansion loops or joints as required.

1.24 OPERATING AND MAINTENANCE MANUALS

A. General: Submit Operating and Maintenance Manual containing the following:
   1. Startup and Shutdown Procedures: Submit a step-by-step write-up of all major equipment. When manufacturer's printed start-up, troubleshooting and shut-down procedures are available, they shall be incorporated into the operating manual for reference.
   2. Operating Instructions: Written operating instructions shall be included for the efficient and safe operation of all equipment.
   3. Equipment List: List of all major equipment as installed shall include model number, capacities, and nameplate data.
      a. Service Instructions: Submit the following information for all pieces of equipment:
      b. Recommended spare parts, including catalog number and the name, address and telephone number of local suppliers of factory representative.
      c. Lubrication and maintenance instructions for all equipment including all electric motors.
   4. Filter, belt sizes, types and lengths.
   5. Detailed list of all control set points and control and wiring diagrams and software.
   6. Testing and Commissioning Sheets detailing all set points, balance figures of air and water systems.
   7. Include in the manuals, parts catalogs for each item of equipment furnished by him with the components identified by number of for replacement ordering.
   8. All as-built drawings and wiring diagrams.
   9. Valve charts organized on a room and sequence basis, detailing room, system and valve numbers.
   10. Manual damper charts organized on a room and system basis, detailing room system and damper number.

B. Submission
   C. Manuals shall be in triplicate, and all materials shall be bound into volumes of standard 8-1/2-inch x 11-inch size shall be separately bound or folded into brown envelopes, cross-referenced and indexed with the manuals.
   D. The manuals shall include the name of the Architect, Contractor and major subcontractors.

E. In order not to duplicate Contractor's efforts, submit preliminary copy of the manual to the Owner’s Representative for a pre-check; and when approved, Contractor shall then submit the final copies.

1.25 FIELD ADJUSTMENT TO AIR HANDLING EQUIPMENT AND FANS

A. Contractor shall be responsible to change or adjust belts, drives, pulleys, motors, impellers, as required by balancing company to achieve the desired air delivery by all air handling equipment.

1.26 RECORD DRAWINGS (AS-BUILTS)

A. In accordance with procedure in Division 1, and the following: indicate and transfer the record conditions as outlined above to the reproducible tracings.

B. Keep a day-to-day record of the installed locations for all equipment as hereinafter listed:

1. All piping concealed in walls, floors, underground, or above inaccessible ceilings. Record need not include any exposed piping or piping above removable ceilings.
2. Duct concealed in walls, underground or above inaccessible ceilings.
3. Volume and fire dampers, smoke dampers and access panels both exposed and concealed.

C. Underground utility services, both inside and outside of buildings, shall be dimensioned from permanent structures or bend mark. Utility services outside of buildings shall also show depth of burial with reference to the finished ground floor elevation.

D. Immediately upon commencing work on the project, obtain a set of prints of the contract drawings pertaining to this branch of work. This set of drawings shall be kept on the project site at all times for use in recording "record" conditions.

E. The record drawings, as corrected and recorded by the Contractor, shall be submitted to the Owner’s Representative for approval prior to authorization for final payment. Record drawings shall be certified as to their correctness by the signature of the Contractor and shall be stamped or otherwise identified as Record Drawings.

1.27 POLLUTANT CONTROL

A. Temporary Ventilation

1. The permanent HVAC system shall only be used during construction if necessary to condition the building or area of addition or alteration within the required temperature range for material and equipment installation. If the HVAC system is used during construction, use return air filters with a minimum efficiency reporting value (MERV) of 8 based on ASHRAE 52.1-1992. Replace all filters immediately prior to occupancy, or, if the building is occupied during alteration, at the conclusion of construction.

B. Covering of duct openings and protection of mechanical equipment during construction

1. At the time of rough installation and during storage on the construction site until final start-up of the heating, cooling and ventilating equipment, all duct and other related air distribution component openings shall be covered with tape, plastic, sheet metal or other methods acceptable to Owner’s representative to reduce the amount of dust, water and debris which may enter the system.

1.28 FINISHING AND CLEANING

A. Clean premises of all excess construction material and debris caused by his work, in accordance with Section 017400, CLEANING AND WASTE MANAGEMENT.

B. Surfaces shall be left clean, debris shall be removed, and equipment shall be furnished in prime coat finish unless otherwise specified.

C. Clean exterior of piping, ductwork and equipment, exposed in complete structure. Remove rust, plaster and dirt by wire brushing; remove grease, oil and similar materials by wiping with clean rags and suitable solvents.

D. Motors, Pumps and Other Items with Factory Finish: Remove grease and oil and leave surfaces clean.

1.29 PAINTING

A. Preparation, priming and finish painting shall be in accordance with Section 099000 – PAINTING AND COATING. Except for the priming and painting work described below, all finish painting work shall be under Section 099000 – PAINTING AND COATING. Painting described below shall be part of the work of this Section.

B. Items to be painted: The following items and ferrous materials shall be "prime coated":

1. Sheet steel or structural steel supports, steel pipe, pipe hangers or supports, outside air volume and control dampers, screens, louvers, and machinery guards.
2. Supply and exhaust fans shall be factory primed.
3. Control cabinets, primed and finish coated prior to mounting controls and gauges.

C. The following items shall have the manufacturer's standard finish:

1. Cast iron valves and cast iron bases.
2. Supply, return and exhaust air diffusers and attached dampers.
3. Vibration mounts.
4. Combination Fire and Smoke, volume and control dampers in conditioned air.

D. Acceptance: Prior to finish painting and final acceptance by Owner's Representative, touch up scratches or blemishes in prime coats and factory finishes.

1.30 FINAL INSPECTION

A. Refer to General Conditions and Division 1.

B. Each piece of equipment comprising part of the mechanical system shall be checked for proper lubrication, drive rotation, belt tension, control sequence and any other condition which may cause improper equipment operation, damage to equipment or endanger personnel.

1.31 PROJECT CLOSE-OUT

A. Refer to General Conditions Article 9 and Section 017800 – CLOSEOUT SUBMITTALS.

B. Deliver tools, spare parts, extra stocks of materials, and similar physical items to Owner.

C. Complete start-up, testing and demonstration of systems to the satisfaction of the Owner's Representative that the entire installation is complete, properly adjusted and is in proper operating condition.

D. Complete final cleaning up requirements.

1.32 GUARANTEE TO REPAIR PERIOD

A. Refer to General Conditions Paragraph 12.2 for 2-year period.

B. Where appropriate, extended guarantee/warranty periods have been specified in individual sections. Refer to Section 017800 – CLOSEOUT SUBMITTALS, for warranty procedure and form.

C. Complete opposite season testing per Cx spec section 019113.

1.33 PRELIMINARY OPERATION AND EMERGENCY REPAIRS

A. Owner reserves the right to operate portions of the mechanical system on a preliminary basis or make emergency repairs without voiding the guarantee or relieving Contractor of its responsibilities.

1.34 SERVICES

A. General: Perform service on all mechanical Work until acceptance of the Work including oiling and greasing, adjustments, cleaning, packing of seals, and other items as recommended by equipment manufacturer in the maintenance manual hereinbefore specified.

B. Air Filters

1. Do not operate air-moving equipment having air filters unless temporary filters, of equal rating to specified, are in place to protect the mechanical Work.
2. Replace these temporary filters with specified filters before final test and balance work is begun as necessary for accurate readings. After completing the testing and balancing work, replace filters with new filter media as specified.

C. Replace insulation removed or damaged after each operation.

D. Put system in full operating condition.

1.35 WARRANTIES

A. The warranty period shall be no less than two (2) full years, unless specified otherwise hereinafter.

B. During the warranty period, the contractor shall guarantee the following in a form satisfactory to the Owner:

1. All Work installed will be free from any and all defects in Workmanship and/or materials.
2. All equipment, apparatus will develop capacities and performance characteristics specified.
3. The systems shall operate without malfunction.

C. The contractor shall, without cost to the Owner, remedy any defects within a reasonable time to be specified in notice from the Architect. In default thereof, the Owner may have such Work done and charge all costs to the Subcontractor.

D. The start of the contractor’s warranty period, as defined in the General Conditions, shall commence on the issue of a “Certificate of Substantial Completion”, by the Owner or the Owner’s Representative for each item of material, equipment or system.

E. All required extended warranty costs for equipment, materials and systems shall be included in the contractor’s proposal.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

SECTION 230500
COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. This section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Grout.
   5. Equipment installation requirements common to equipment sections.
   6. Painting and finishing.
   7. Concrete bases.
   8. Supports and anchorages.

B. Related Sections
   1. Section 230000 – BASIC MECHANICAL REQUIREMENTS.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, 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 chases.

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 standard abbreviations:
   1. CWP: Cold Water Pressure

G. The following are industry abbreviations for plastic materials:
   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PE: Polyethylene plastic.
   3. PVC: Polyvinyl chloride plastic.
   4. PTFE: Polytetrafluoroethylene plastic.
   5. TFE: Tetrafluoroethylene plastic.

H. The following are industry abbreviations for rubber materials:
   1. BR: Butyl rubber.
   2. Buna-N: Nitrile rubber.
   3. CR: Chlorosulfonated polyethylene synthetic rubber.
   4. CSM: Chlorosulfonyl-polyethylene rubber.
   5. EPDM: Ethylene-propylene-diene terpolymer rubber.
   6. NR: Natural rubber.
   7. PTFE: Polytetrafluoroethylene plastic.

1.3 SUBMITTALS

A. Product Data for the following:
   1. Transition fittings.
   2. Dielectric fittings.

B. Welding certificates.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
   3. Welding procedures, welders, and welding operators for all building service piping to be in accordance with certified welding procedures of the National Certified Pipe Welding Bureau and Section 927.5 of ASME B31.9 Building Services Piping or AWS 10.9 Qualification of Welding Procedures and Welders for Piping and Tubing. Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section 927.6 of ASME B31.9 Building Services Piping.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 COMMISSIONING

A. Division 23 will be responsible to carry out the Commissioning Requirements specified in 019113 – COMMISSIONING REQUIREMENTS.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

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

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

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 083100 – ACCESS DOORS AND FRAMES.

1.8 TRAINING OF OWNER'S PERSONNEL

A. Confirm training requirements listed below with the Owner.

B. Furnish the Owner’s designated personnel with five, 8-hour days of training and instruction. The training and instruction sessions shall be conducted at the Owner's convenience.

C. All training of personnel shall be completed before final inspection.

D. All training shall be conducted within the project boundaries. If this is not possible, all the costs associated with travel, room and board of the Owner’s Personnel selected to attend the training session shall be at no additional cost to the Owner.

E. All training shall be videotaped and submitted to Owner for their record.

PART 2 PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Manufacturers
      a. Eslon Thermoplastics.
      b. Or equal.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
   1. Manufacturers
      a. Thompson Plastics, Inc.
      b. Or equal.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Manufacturers
    a. NIBCO, Inc.
    b. Or equal.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

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

C. Dielectric-Flange Kits: Flange isolation kit complete with neoprene-faced phenolic full-faced gasket, double phenolic washers, double steel washers and phenolic sleeves. ANSI rated 150 psi, 100 degree F maximum temperature.
    1. Manufacturers
        a. Hoff company Inc.
        b. Pipeline Seal and Insulator, Inc.
        c. Or equal.

D. Dielectric Nipples: Electroplated steel nipple with inert, NSF/FDA listed and noncorrosive, thermoplastic lining; minimum 3-inch long; plain, threaded, or grooved ends; and ASTM- F-492, and 300 psig minimum working pressure at 225 degrees F.
    1. Manufacturers
        a. Clear Flow.
        b. Or equal.

2.5 MECHANICAL SLEEVE SEALS

A. Refer to Section 230517 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING.

2.6 SLEEVES

A. Refer to Section 230517 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING.

2.7 ESCUTCHEONS

A. Refer to Section 230518 – ESCUTCHEONS FOR HVAC PIPING.

2.8 GROUT

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

2.9 ACCESS PANELS

A. Refer to Section 083100 – ACCESS DOORS AND FRAMES.

B. Submit sample of access panel for approval by the Owner’s Representative.

PART 3 EXECUTION

3.1 PIPING SYSTEMS – COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

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

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

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to Section 231518 – ESCUTCHEONS FOR HVAC PIPING.

M. Install sleeves for pipes passing through concrete and masonry walls, and concrete floor and roof slabs according to Section 230517 – SLEEVES AND SLEEVE-SEALS FOR HVAC PIPING.

N. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 078400 – FIRE SAFING – FIRE STOPPING.

O. Hot pipes penetrating roof membranes shall be fitted with a welded cowl and air space between cowl and flashed curb shall allow for thermal expansion.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

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

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

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

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated
1. Install unions, in piping NPS 2 and smaller, at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Piping Systems: Install dielectric flange kits or dielectric nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Sections 099000 – PAINTING AND COATING.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 055000 – METAL FABRICATIONS FOR STRUCTURAL STEEL.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.7 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8 TESTING

A. The Owner’s Representative reserves the right to test the work of any welder employed on the project, at the Owner's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project and all defective welds replaced.

3.9 ACCESS PANELS

A. Provide all ceiling and wall mounted access panels to all equipment requiring operation or maintenance access including, but not limited to, combination fire and smoke dampers, fans, fan coil units, air terminal units, valves, control devices and duct access doors. Locations shall be shown on shop drawings and shall be approved by the Owner’s Representative prior to framing and installation of panel. Whenever possible locate panels in order to utilize single panel to access multiple devices. Coordinate location of panels with work specified in other sections. Equipment and valves shall be within easy reach of opening without necessitating personnel to stretch or leave access platform.

B. Access panels shall be minimum 18 inches x 18 inches where partial body access is required and minimum 24 inches x 24 inches where fully body access is required.

3.10 VARIABLE FREQUENCY DRIVES

A. All variable frequency drives in project shall be from the same manufacturer.

3.11 FLASHINGS

A. Each pipe, duct or gas-fired equipment vent passing through roof shall be flashed with a waterproof flashing.

B. Flashings or flanges on pipes, vents, and ducts passing through a tile or slate roof shall be constructed of sheet lead. Flashing for pipes and heater vents passing through roofs other than tile or slate shall be galvanized sheet metal or aluminum. Flashing and flanges for ducts through roofs other than tile or slate and through exterior walls shall be same material and gage as duct. All flanges and flashing shall be made waterproof at point of connection with pipe or duct.

C. All cast iron, steel, brass and copper pipe, which terminate less than 18 inches above roof, shall be equipped with a combination counter-flashing and vandal-proof hood for protection against water, birds and foreign matter. All cast iron, steel, brass and copper pipe, which do not terminate within 18 inches of roof, shall be equipped with a counter-flashing sleeve.

D. Pipe, which terminates more than 18 inches above roof, shall have end protected against entrance of water, birds and foreign matter.

E. Flashing and flanges on ducts shall be made waterproof at point of connection to the duct by riveting and soldering. Storm collars shall be securely screwed and made waterproof, around appliance vent pipe, immediately above flashing. All vent piping above roof shall be equipped with a combination counter-flashing sleeve and vandalproof hood.

END OF SECTION

SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

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

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 COORDINATION

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

1.3 SUBMITTALS

A. Submit test results verifying nominal efficiency and power factor for three phase motors larger than 5 HP.

B. Operation and Maintenance data to include assembly drawings, bearing data including replacement sizes, installation instructions and lubrication instructions.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.5 WARRANTY

A. Manufacturer agrees to repair or replace motor that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Baldor
   2. Reliance
   3. Marathon
   4. Century

5. Or equal.

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Motors shall be UL listed.

D. Comply with the requirements of the California Electrical Code.

E. Three phase motors shall be premium efficiency type unless otherwise noted to meet or exceed the IEEE841 Standards for efficiency and to meet 1994 requirements of Energy Policy Act of 1992.

F. Motors efficiencies shall be guaranteed minimum values in accordance with the following table. Efficiencies shall be established in accordance with NEMA Test Standards MG1-12.53A using IEEE Test Procedure 112, method B.

G. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor and efficiency.

2.3 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degrees C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Starting Torque: Between one and one and one-half times full load torque.

E. Starting Current: Six times full load current or more.

F. Multispeed Motors: Separate winding for each speed.

G. Rotor: Random-wound, squirrel cage.

H. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. Rated for minimum ABMA, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V- belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

I. Temperature Rise: one class below insulation rating class.

J. Insulation: Class F.

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

L. Thermister System (Motor Frame Sizes 254T and Larger): Three PTC thermisters imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.

M. Sound Power Levels: To ANSI/NEMA MG 1.

N. Part winding start above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

O. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure coat windings with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.

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

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Variable Frequency Controllers
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Motors shall be inverted duty rated when used with variable frequency drives
   3. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   4. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   5. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   6. Do not provide power factor capacitor.

2.6 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 HP shall be one of the following, to suit starting torque and requirements of specific motor application
   1. Permanent-split capacitor.
      a. Starting Torque: Exceeding one fourth of full load torque.
      b. Starting Current: Up to six times full load current or more.
      c. Multiple Speed: Through tapped windings.
      d. Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, automatic reset overload protector.
   2. Split phase.
      a. Starting Torque: Less than 150 percent of full load torque.
      b. Starting Current: Up to seven times full load current.
      c. Breakdown Torque: 200 percent of full load torque.
      d. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
   3. Capacitor start, inductor run.
      a. Starting Torque: Three times full load torque.
      b. Starting Current: Less than five times full load current.
      c. Pull-up Torque: Up to 350 percent of full load torque.
      d. Breakdown Torque: Approximately 250 percent of full load torque.
      e. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
   4. Capacitor start, capacitor run.
      a. Starting Torque: Three times full load torque.
      b. Starting Current: Less than five times full load current.
      c. Pull-up Torque: Up to 350 percent of full load torque.
      d. Breakdown Torque: Approximately 250 percent of full load torque.
      e. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
      f. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

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

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation.

Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.7 COUPLINGS

A. Couplings for direct drive equipment shall be flexible, self-aligning, non-lubricating type, rated at least 125 percent of motor rated horsepower.

B. Manufacturer
   1. Fast's Standard
   2. John E. Lisee Pump, Inc.
   3. Or equal.

2.8 BELT DRIVES AND SHEAVES

A. General: Belt drives shall be V-belt type with appropriate sheaves.

B. Sheaves: Sheaves shall be cast iron, machined and balanced.

C. Ratings: Belt drives shall be a minimum of 200 percent of motor nameplate rating.

D. Manufacturer
   1. Browning
   2. Dodge
   3. Gates
   4. Or equal.

2.9 GUARDS

A. General: All rotating elements on equipment shall have protective devices in accordance with the CCR Title 8, Division of Industrial Safety and General Industry Safety Orders and OSHA requirements.

B. Coupling guards shall completely enclose the rotating coupling and shall be constructed of heavy gage steel in accordance with OSHA requirements.

C. Belt Guards
   1. Guards shall totally enclose the belts and sheaves. Guards shall be fabricated of galvanized expanded metal sides, solid galvanized steel band and adequately sized galvanized angle iron frame.
   2. Tachometer holes with covers shall be provided for both sheaves.

PART 3 EXECUTION

3.1 APPLICATION

A. All motors installed within the air stream to be Open Drip Proof (ODP).

B. All motors installed out of the air stream to be Totally Enclosed Fan Cooled (TEFC).

C. Where control panel is specified the panel shall have single point feeder, across-the-line magnetic starters, HOA switches, overload protection.

D. Motors drawing less than 250 Watts and intended for intermittent service may be standard of equipment manufacturer and need not conform to these specifications.

E. Single phase motors for centrifugal pumps: split phase type.

F. Single phase motors for shaft mounted fans or blowers: permanent split capacitor type.

G. Motors located in direct drive axial fans, explosion proof environments: totally enclosed type.

H. Motors located in wet air streams: totally enclosed weatherproof epoxy-treated type.

I. Motors located in exterior locations: totally enclosed weatherproof epoxy-sealed type.

J. Motors less than 1/2 HP: single phase.

K. Motors equal to or greater than 1/2 HP: 3 phase totally enclosed fan cooled unless as stated in otherwise in this specification.

3.2 INSTALLATION

A. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame.

B. Motors 10 HP and smaller shall be provided with variable pitch sheaves and installed on motor slide rails.

C. Motors 15 HP and larger shall have non-adjustable drive sheave and be installed on motor slide rails.

3.3 PERFORMANCE

A. Motors shall meet the following minimum efficiency:

Open Drip Proof (ODP)				Totally Enclosed Fan Cooled (TEFC)			
Motor HP	1200 rpm	1800 rpm	3600 rpm	Motor HP	1200 rpm	1800 rpm	3600 rpm
	Efficiency	Efficiency	Efficiency		Efficiency	Efficiency	Efficiency
1	82.5	85.5	77.0	1	82.5	85.5	77.0
1.5	86.5	86.5	84.0	1.5	87.5	86.5	84.0
2	87.5	86.5	85.5	2	88.5	86.5	85.5
3	88.5	89.5	85.5	3	89.5	89.5	86.5
5	89.5	89.5	86.5	5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	7.5	91.0	91.7	89.5
10	91.7	91.7	89.5	10	91.0	91.7	90.2
15	91.7	93.0	90.2	15	91.7	92.4	91.0
20	92.4	93.0	91.0	20	91.7	93.0	91.0
25	93.0	93.6	91.7	25	93.0	93.6	91.7
30	93.6	94.1	91.7	30	93.0	93.6	91.7

3.4 COUPLINGS

A. Coupling halves shall be keyed and locked on shafts.

3.5 BELT DRIVES AND SHEAVES

A. General
   1. Belts shall be based on load requirements.
   2. After air balance is completed and air balance has been accepted by the Owner’s Representative, change each variable pitch sheave to fixed pitch sheave.

B. Sheaves
   1. Variable pitch sheaves shall be selected for mid-point of equipment operating capacity.
   2. Sheaves shall be keyed and located on shafts, with Allen head set screws. On fractional horsepower motors on NEMA frame size 48, smaller sheaves may be secured to shaft with set screws only.

3.6 GUARDS

A. Adequate room for belt adjustments shall be provided.

END OF SECTION

SECTION 230516
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Expansion Compensators
   2. Flexible Hose Expansion Joints
   3. Pipe Bends and Loops
   4. Alignment Guides and Anchors

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 PERFORMANCE REQUIREMENTS

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

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

C. Provide and install supports and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints.

D. Pressure Rating for CWP: 200 psig unless indicated otherwise

1.3 SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

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

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

E. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.1 EXPANSION JOINTS

A. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, anti-torque device, and removable end clip for positioning.
   1. Product: Provide product by one of the following:
      a. Metraflex, Inc.
      b. Hyspan Precision Products, Inc.
      c. Unaflex Inc.
      d. Or equal.
   2. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows, and bronze or stainless-steel shroud.
   3. Configuration for Steel Piping: Two-ply stainless-steel bellows and stainless steel shroud.
   4. End Connections for Copper Tubing NPS 2 and Smaller: Threaded.
   5. End Connections for Copper Tubing NPS 2-1/2: Threaded.
   6. End Connections for Steel Pipe NPS 3 to NPS 4: Flanged.
   7. End Connections for Steel Pipe NPS 4 and larger: Welded.

B. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
   1. Product: Provide product by one of the following:
      a. Metraflex, Inc.
      b. Flex-Hose Co., Inc.
      c. Or equal.
   2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.
      a. NPS 2-1/2 and smaller: Bronze hoses and double-braid bronze sheaths with maximum working pressure 350 psig at 70 degrees F and 273 psig at 400 degrees F ratings.
   3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with flanged end connections for NPS 2-1/2 and larger.
      a. NPS 3 to NPS 6: Stainless-steel hoses and double -braid, stainless-steel sheaths with maximum working pressure 300 psig at 70 degrees F and 222 psig at 600 degrees F ratings.
      b. NPS 8 to NPS 12: Stainless-steel hoses and double-braid, stainless-steel sheaths with maximum working pressure 165 psig at 70 degrees F and 120 psig at 600 degrees F ratings.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
   1. Product: Provide product by one of the following:
      a. Metraflex, Inc.
      b. Flex-Hose Co., Inc.
      c. Hyspan Precision Products, Inc.
      d. Or equal.

2.3 MATERIALS FOR ANCHORS

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

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, and tension and shear capacities appropriate for application.
   1. Stud: Threaded, zinc-coated carbon steel.
   2. Expansion Plug: Zinc-coated steel.

3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened Portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

F. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink, non-metallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000 psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

D. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.

E. Provide expansion compensators in piping systems only where expansion loops cannot physically be installed. Provide pipe guides on all piping with expansion loops. Provide design and installation of all pipe anchors for thermal and seismic expansion joints.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

C. Install pipe guides for the first three supports upstream and downstream of each expansion device including expansion loops.

3.4 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION

SECTION 230517
SLEEVE AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Sleeves.
   2. Sleeve-seal Systems.
   3. Grout.

B. This project is required to achieve certification under LEED-CI v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

PART 2 PRODUCTS

2.1 SLEEVES

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

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Provide products by one of the following:
   1. Metraflex Company.
   2. Advance Products & Systems, Inc.
   3. CALPICO, Inc.
   4. Or equal.

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

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION

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

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

C. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/2-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 – JOINT SEALANTS.

D. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078400 – FIRE SAFING – FIRE STOPPING.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in slabs-on-grade or below grade exterior walls at piping entries into building.

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

3.3 SLEEVE AND SLEEVE SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. Exterior Concrete Walls above Grade: Cast-iron wall sleeves.
   2. Concrete Slabs-on-Grade: Cast-iron sleeves with sleeve-seal system.
   3. Concrete Slabs above Grade:
      a. Piping Smaller Than NPS 6: Cast Iron Sleeves.
      b. Piping NPS 6 and Larger: Cast Iron Sleeves.
   4. Interior Concrete Partitions
      a. Piping Smaller Than NPS 6: Cast Iron Sleeves.
      b. Piping NPS 6 and Larger: Cast Iron Sleeves.

END OF SECTION

SECTION 230518
ESCUTCHEONS FOR HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Escutcheons.
   2. Floor plates.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

PART 2 PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 EXECUTION

3.1 INSTALLATION

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

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.

C. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 230519
METERS AND GAGES FOR HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Thermometers
   2. Gages
   3. Test Plugs
   4. Flowmeters

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 WARRANTY

A. Manufacturer agrees to repair or replace device that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Provide product by one of the following:
   1. Trerice, H. O. Co.
   2. Marsh Bellofram.
   3. Weiss Instruments, Inc.
   4. Or equal.

B. Standard: ASME B40.200.

C. Case: Die-cast aluminum or Chrome-plated brass, 9-inch long.

D. Tube: Mercury or red or blue organic-liquid filled, with magnifying lens.

E. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

F. Window: Plastic.

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

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

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

2.2 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Provide product by one of the following:
   1. Trerice, H. O. Co.
   2. Marsh Bellofram.
   3. Weiss Instruments, Inc.
   4. Or equal.

B. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.

C. Element: Phosphor Bronze bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass.

H. Ring: Close type, Stainless steel.

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

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

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

2.3 THERMOWELLS

A. Provide product by one of the following:
   1. Trerice, H. O. Co.
   2. Marsh Bellofram.
   3. Weiss Instruments, Inc.
   4. Or equal.

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

2.4 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.5 PRESSURE GAGES

A. Provide product by one of the following:
   1. Trerice, H. O. Co.
   2. Marsh Bellofram.
   3. Weiss Instruments, Inc.
   4. Or equal.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
   1. Case: Liquid Filled, drawn steel or cast aluminum, 4-1/2-inch diameter.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
   3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
   4. Movement: Mechanical, with link to pressure element and connection to pointer.
   5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
   6. Pointer: Red or other dark-color metal.
   7. Window: Glass.

8. Ring: Stainless steel.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.
12. Pressure Rating: 300 psig at 200 deg F.

C. Pressure-Gage Fittings
   1. Valves: NPS 1/4 stainless-steel needle type.
   2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
   3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.6 TEST PLUGS

A. Provide product by one of the following:
   1. Trerice, H. O. Co.
   2. Flow Design, Inc.
   3. Sisco Manufacturing Co.
   4. Watts Industries, Inc.; Water Products Div.
   5. Or equal.

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

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

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for air and water service at 20 to 200 deg F shall be CR.
   2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
   1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.
   2. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 250 deg F.
   3. Carrying case shall have formed instrument padding.

2.7 ULTRASONIC FLOWMETERS:

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Eastech Badger, Inc. (Vantage 4000)
   2. Siemens (Sitrans FUS1010).
   3. General Electric (AquaTrans AT868)
   4. Engineering Measurements Company (Sono-Trak Transit Time Ultrasonic)
   5. Or equal.

B. Pressure Rating: 150 psig.

C. Temperature Rating: 180 deg F minimum.

D. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.

E. Flow Sensor: Transit-time, externally mounted, clamp-on, ultrasonic type with transmitter.

F. Temperature Sensors: Insertion-type or strap-on transducer.

G. Indicator: Solid-state, integrating-type meter with integral battery pack.
   1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
   2. Battery Pack: Five-year lithium battery.

H. Select either 1 percent or 5 percent accuracy below depending on project requirements. Note that the GE AquaTrans cannot achieve ±1 percent with a clamp on type sensor and will need to be removed from the listed manufacturers if ±1 percent is selected.

I. Accuracy: Plus or minus 1 percent of actual flow.

J. Turn-down: 400:1.

K. Repeatability: 0.25 percent.

L. Display: Visually indicates instantaneous rate of flow with register to indicate total fluid volume in gallons and thermal-energy flow in British thermal units.

M. Strainer: Full size of main line piping.

N. Outputs: Min. one 4-20 mA isolation circuit. Output connections to be compatible with EMCS.

O. Provide Analogue Output for connection to Energy Management Control System for flow totalization.

2.8 TURBINE FLOWMETERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Eastech Badger, Inc.
   2. Bailey-Fischer & Porter Co.
   3. Data Industrial Corp.
   4. ONICON Incorporated.
   5. Or equal.

B. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.

C. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

D. Pressure Rating: 150 psig.

E. Temperature Rating: 180 deg F minimum.

F. Display: Visual instantaneous rate of flow, with register to indicate total volume in gallons.

G. Accuracy: Plus or minus 2-1/2 percent.

H. Provide Analogue Output for connection to Energy Management Control System for flow totalization.

PART 3 EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations, and where indicated on the drawings:
   1. Inlet and outlet of each boiler.
   2. Outside-air, return-air and mixed-air ducts.

B. Install direct-mounting, vapor-actuated dial thermometers in the following locations, and where indicated on the drawings:
   1. Inlet and outlet of each hydronic coil in air-handling units or built-up central systems.
   2. Inlet and outlet of all hydronic lines entering and leaving mechanical rooms.
   3. Heating hot water supply and return mains into the building.

C. Install dry liquid-filled-case-type, vapor-actuated dial thermometers at suction and discharge of each pump.

D. Provide the following temperature ranges for thermometers:
   1. Heating Hot Water: 30 to 240 degrees F, with 2-degree scale divisions.
   2. Chilled Water: 0 to 100 degrees F, with 2-degree scale divisions.

3. Air Ducts: 30 to 120 degrees F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

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

B. Install liquid filled type pressure gages at chilled water lines entering and leaving the building.

C. Install liquid filled type pressure gages at suction and discharge of each pump, installing taps before strainers and on suction and discharge of pump.

3.3 METER APPLICATIONS

A. Install ultrasonic flow meter on chilled and hot water system prior to leaving mechanical room.

B. Install turbine flow meters on make-up water connection to hot water system.

3.4 INSTALLATIONS

A. Provide thermowells for each thermometer. The thermowells shall be selected for each gauge bulb and shall be 1/2-inch NPT. Enlarge pipes smaller than 2-1/2 inch for a length of 12 inches for installation of thermowells

B. Provide and select bulbs suitable for service pressure.

C. Install direct-mounting thermometers and adjust vertical and tilted positions. Make sure the thermometers are installed upright for easy reading.

D. Install thermowells adjacent to controls system thermostat, transmitter, or sensor sockets.

E. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

F. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

G. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position. Make sure the gages are installed upright for easy reading.

H. Install pressure gages with pulsation dampers.

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

J. Install test plugs in tees in piping.

K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.

L. Install flowmeter elements in accessible positions in piping systems.

M. Install flowmeter elements with at least minimum straight lengths of 10 pipe diameters upstream and minimum 5 pipe diameters downstream from element or as prescribed by manufacturer's written instructions.

N. Install permanent indicators on walls or brackets in accessible and readable positions.

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

P. Mount meters on wall if accessible; if not, provide brackets to support meters.

Q. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

3.5 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters and building control system.

3.6 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjust faces of thermometers and gages to proper angle for best visibility. Make sure the thermometers and gages are installed upright for easy reading.

END OF SECTION

SECTION 230523
GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Bronze ball valves.
   2. Bronze lift check valves.
   3. Bronze swing check valves.
   4. Iron, single-flange butterfly valves.
   5. Iron, grooved-end butterfly valves.
   6. Iron, grooved-end swing-check valves.
   7. Iron swing check valves with closure controls.
   8. Chainwheels.

B. Related Sections
   1. Section 230553"IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT " for valve tags and schedules.
   2. Section 230923 – INSTRUMENTATION AND CONTROL FOR HVAC FOR CONTROL VALVES AND ACTUATORS.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

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

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

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

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

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set ball valves open to minimize exposure of functional surfaces.

4. Set butterfly valves closed or slightly open.
5. Block check valves in either closed or open position.

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

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

1.6 WARRANTY

A. Manufacturer agrees to repair or replace valve that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule for applications of valves.

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

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

D. Valve Actuator Types
   1. Handlever: For quarter-turn valves NPS 6 and smaller.
   2. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

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

F. Valve-End Connections
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Threaded: With threads according to ASME B1.20.1.
   3. Grooved: With grooves according to AWWA C606.

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

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim
   1. Manufacturers:
      a. NIBCO T-585-Y-70-66.
      b. Hammond.
      c. Or equal.
   2. Description
      a. Standard: MSS SP-110.
      b. CWP Rating: 600 psig.
      c. Body Design: Two piece.
      d. Body Material: Bronze.
      e. Ends: Threaded.
      f. Seats: PTFE or TFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel, vented.
      i. Port: Full.

2.3 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Nonmetallic Disc
   1. Manufacturers:
      a. NIBCO T-480-Y
      b. Hammond Valve
      c. Or equal.
   2. Description
      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig.
      c. Body Design: Vertical flow.
      d. Body Material: ASTM B 61 or ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: PTFE, or TFE.

2.4 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Nonmetallic Disc
   1. Manufacturers:
      a. NIBCO T-433-Y
      b. Hammond Valve
      c. Or equal.
   2. Description
      a. Standard: MSS SP-80, Type 4.
      b. CWP Rating: 300 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: PTFE or TFE.

2.5 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc
   1. Manufacturers:
      a. NIBCO LD-3022
      b. Hammond Valve
      c. Or equal.
   2. Description
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      e. Seat: EPDM.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Stainless steel.

2.6 IRON, GROOVED-END BUTTERFLY VALVES

A. 300 CWP, Iron, Grooved-End Butterfly Valves
   1. Manufacturers:
      a. Victaulic Company, VIC-300 Masterseal.
      b. Or equal.
   2. Description
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 300 psig.
      c. Body Material: Coated, ductile iron.
      d. Stem: Two-piece stainless steel.
      e. Disc: Aluminum Bronze or Stainless Steel.
      f. Seal: EPDM.

2.7 IRON, GROOVED-END SWING CHECK VALVES

A. 250 CWP, Iron, Grooved-End Swing Check Valves
   1. Manufacturers:
      a. NIBCO GD-920-W
      b. Anvil International, Inc.
      c. Shurjoint Piping Products
      d. Victaulic Company
      e. Or equal.
   2. Description
      a. CWP Rating: 250 psig.
      b. Body Material: ASTM A 536, ductile iron.
      c. Seal: EPDM or Buna-N.
      d. Disc: Spring operated, ductile iron or stainless steel.

2.8 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control
   1. Manufacturers:
      a. NIBCO F-918-BLW.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
      d. Or equal.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.
      h. Closure Control: Factory-installed, exterior lever and weight.

2.9 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries
   3. Trumbull Industries.
   4. Or equal.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to butterfly valve stems.
   3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
   4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

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

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

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

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

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

3.2 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

E. Provide 3/4-inch ball drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest drain.

F. Install chainwheels on operators for butterfly, gate and globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

G. Equipment with automatic control valves shall have isolation valves installed either ahead or behind the control valve, to permit removal of the control valve from the line without draining the system.

H. Line valves 4 inches and above shall be supported at valve in addition to regularly spaced pipe supports.

I. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

J. When valves are installed above ceilings accessible through an access panel, locate valve not more than 2.5 feet from the access panel opening sized 24"x 24" and install valves directly above an access panels smaller than 24"x24". This does not apply to valves provided with chainwheels.

3.3 JOINT CONSTRUCTION

A. Refer to Section 230500 – COMMON WORK RESULTS FOR HVAC for basic piping joint construction.

B. Refer to Section 232113 – HYDRONIC PIPING for piping application.

C. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.4 ADJUSTING

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

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball or butterfly valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Pump-Discharge Check Valves
      a. NPS 2-1/2 and Smaller: Bronze swing check valves with nonmetallic disc.
      b. NPS 3 and Larger: Iron swing check valves with lever and weight, resilient-seat check valves.

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

C. Select valves with the following end connections:
   1. For Copper Tubing, NPS 2-1/2 and Smaller: Threaded ends.
   2. For Steel Piping, NPS 3 and Larger: Flanged ends.
   3. For Grooved-End Copper Tubing and Steel Piping, valve ends may be grooved.

3.6 CHILLED WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller
   1. Bronze Ball Valves: Two-piece, full port, with stainless-steel trim.
   2. Bronze Swing Check Valves: Class 150, non-metallic disc.

B. Pipe NPS 2-1/2 and Larger
   1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, NBR seat, stainless-steel disc.
   2. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 300 CWP.
   3. Iron Swing Check Valves with Closure Control, NPS 3 to NPS 12: Class 125, lever and spring or weight.
   4. Iron, Grooved-End Check Valves, NPS 2-1/2 to NPS 12: 250 CWP.

3.7 HEATING HOT WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller
   1. Bronze Ball Valves: Two-piece, full port, with stainless-steel trim.
   2. Bronze Swing Check Valves: Class 150, nonmetallic disc.

B. Pipe NPS 3 and Larger
   1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, NBR seat, stainless-steel disc.
   2. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 300 CWP.
   3. Iron Swing Check Valves with Closure Control, NPS 3 to NPS 12: Class 125, lever and spring or weight.
   4. Iron, Grooved-End Check Valves, NPS 2-1/2 to NPS 12: 250 CWP.

END OF SECTION

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.

B. Related Sections include the following:
   1. Sections 233113 – METAL DUCTS for duct hangers and supports.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from Owner’s Representative.

1.4 SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional civil engineer licensed in the State of California. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe Stands.
   4. Equipment supports.

C. Welding certificates.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

E. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel." AWS D1.3, "Structural Welding Code--Sheet Steel." AWS D1.4, "Structural Welding Code--Reinforcing Steel." ASME Boiler and Pressure Vessel Code: Section IX.

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.2, "Structural Welding Code--Aluminum."
   3. AWS D1.3, "Structural Welding Code--Sheet Steel."
   4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   5. ASME Boiler and Pressure Vessel Code: Section IX.

C. The pipes and ducts shall be supported and braced per the SMACNA “Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems” or the “Superstrut Seismic Restraint System” or the “Kin Line” seismic restraint system for pipes only. All piping support systems shall comply with the "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems" and shall conform to the current adopted edition of the CBC and the California Code of Regulations.

PART 2 PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Manufacturers
   1. B-Line Systems, Inc.; a division of Cooper Industries
   2. Grinnell Corp.
   3. Tolco Inc.
   4. Or equal.

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

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. Manufacturers
   1. B-Line Systems, Inc.; a division of Cooper Industries
   2. Grinnell Corp.
   3. Tolco Inc.
   4. Or equal.

B. Description: MFMA-4, shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.

C. Channels: Continuous slotted steel channel with inturned lips.

D. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

E. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

F. Metallic Coating: Electroplated zinc or hot-dipped galvanized.

G. Non-metallic Coatings: Plastic coating, jacket, or liner.

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers
      a. Powers Fasteners.
      b. Hilti, Inc.
      c. ITW Ramset / Red Head.
      d. Or equal.

3.1 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers
   1. ERICO/Michigan Hanger Co.
   2. Pipe Shields, Inc.
   3. Value Engineered Products, Inc.
   4. Or equal.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation materials with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100 psig minimum compressive strength and vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100 psig minimum compressive strength.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

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

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

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.6 PIPE STANDS

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

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

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

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

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "ROOF ACCESSORIES" for curbs.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

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

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

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

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

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

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

3.5 PAINTING

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

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

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Painting Sections.

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

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

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

F. Use stainless-steel or corrosion-resistant attachments for hostile environment applications.

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

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

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

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

   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8.
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.

8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 8, if longer ends are required for riser clamps.

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

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

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types
    1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
    2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
    3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

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

Q. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230548
VIBRATION AND SEISMIC CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Freestanding and restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
   10. Resilient pipe guides.
   11. Restrained vibration isolation roof-curb rails.
   12. Seismic snubbers.
   13. Restraining braces and cables.
   14. Steel and inertia, vibration isolation equipment bases.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. ASCE: American Society of Civil Engineers

B. CBC: 2013 California Building Code

C. IBC: 2013 International Building Code.

D. ICC-ES: ICC-Evaluation Service.

1.3 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading
   1. Refer to General Notes on Structural drawings for wind speed, building classification category and load requirements.

B. Seismic-Restraint Loading
   1. Refer to General Notes on Structural Drawings for site classification, building category and general load requirements.
   2. Refer to Table 13.6-1 in the ASCE 7-05 for equipment seismic coefficients for mechanical components.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
      c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.
      d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide M.W. Saussé & Co., Inc., (Vibrex) or a comparable product by one of the following:
   1. Mason Industries.
   2. Kinetics Noise Control.
   3. Or equal.

B. General Requirements
   1. Provide a maximum of four vibration isolators located at the corners of the equipment unless approval is obtained for additional isolators.
   2. All vibration isolators shall have markings indicating known undeflected heights.
   3. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves must be linear over a deflection range 50% above the design deflection.
   4. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
   5. The ratio of lateral to vertical stiffness shall not be less than 0.5 or greater than 1.0.
   6. The vertical static deflection for each support point, based upon the load per isolator and isolator stiffness, shall not differ by more than + or - 10%.
   7. Isolation above the resonant frequency shall follow the theoretical prediction based upon an undamped single degree of freedom system.
   8. All neoprene mountings shall have a shore hardness of 50 to 60 after minimum aging of 20 days or corresponding oven aging.
   9. All vibration isolation equipment including but not limited to isolators, mountings, brackets, frames etc. that are exposed to moisture or an outdoor environment shall be coated as follows
      a. All steel parts to be hot-dipped galvanized.
      b. All bolts to be cadmium plated.
      c. All springs to be cadmium plated and neoprene coated.
   10. Design deflections for vibration isolators shall be as listed in the Vibration Isolation Schedule, except in the event of unacceptable levels of vibration when the equipment is in operation, due to any of the resonances of the isolated systems coupling, by coincidence, with any of the resonances of the building structure. In this event, the contractor shall bear the cost of changing the isolators to alter the natural frequencies of the isolated systems so that the amplitude of structural vibrations is reduced to acceptable levels.

C. Pads Type P1: Neoprene Pad(s) and Bearing Plate(s): Neoprene pad shall be ribbed or waffled, 5/16 to 1/2 inch thick, 40 durometer, with a minimum 1/16-inch-thick steel bearing plate on top. Size pad and bearing plate to receive 60 psi load. Provide single or multiple pads and plates in series as specified, with 1/16-inch-thick steel shim between layers. Provide "RPG-EQ" by M.W. Sausse & Co., Inc., or equal.

D. Pads Type P2: Extra Thick Neoprene Pad(s) and Bearing Plate(s): Neoprene pad shall be waffled, 3/4 inch thick, 30 or 40 or 50 durometer, as scheduled, with a minimum 1/16-inch thick steel bearing plate on top. Pad areas shall be selected so no more than 15% and no less than 10% deflection occurs due to the supported load. Provide single or multiple pads and plates in series as specified with 1/16-inch-thick steel shim between layers. Provide "ICPG-EQ" by M.W. Sausse & Co., Inc., or equal.

E. Pads Type P3: Neoprene Bushing for Bolt Holes in Pads: Bushings shall be minimum 3/16" thick in all places and maximum 40 durometer. Provide steel washer to distribute bolt head loads to bushing. Provide bushings by M.W. Sausse & Co., Inc., or equal.

F. Type D: is a molded neoprene element enclosed by a ductile housing. The isolator may be utilized in compression, shear or tension. The isolator shall provide seismic restraint in any direction up to 1.0g. Provide “FUD-EQ" by M.W. Sausse & Co., Inc., or equal.

G. Spring Isolator S1: Unhoused Spring: Springs shall be designed and installed so their ends are parallel before and after installation and during equipment operation.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
6. Baseplate: Each isolator shall have a steel base plate with mounting bolt holes and a ribbed or waffled neoprene friction pad permanently adhered to the bottom. The pad shall be 5/16 to 1/2 inch thick, 40 durometer hardness, and sized for a load of 60 psi. Provide "RMS” by M. W. Sausse & Co., Inc., or equal.

H. Restrained Spring Isolators RS1: Spring with Seismic Restraint and Vertical Travel Limit: with the addition of steel columns on either side of the spring to provide seismic restraint and accommodate vertical travel limit stops. Provide “RMLS-EQ or RMU-EQ-SH” by M.W. Sausse & Co., Inc., or equal.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate permanently bonded to a friction pad of 5/16 to 1/2 inch-thick ribbed or waffled neoprene isolator pad, 40 durometer hardness, and sized for a load of 60 psi attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Mount shall resist a seismic acceleration in any direction of at least 0.5 G or as required by the relevant codes. Travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4 inch shall be maintained around restraining bolts and between the limit stops and the spring so as not to interfere with the spring action.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

I. Elastomeric Hangers H1: A double-deflection neoprene-in-shear element contained in a steel housing. It shall be formed with a projecting neck bushing for the hole in the hanger housing that will prevent metal-to-metal contact between the hanger rod and the housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30o arc before contacting the hanger housing. Neoprene shall be no harder than 50 durometer. Provide "HSS” by M.W. Sausse & Co., Inc., or equal.

J. Spring Hanger H2: Vibration isolation hangers shall contain a laterally-stable steel spring set in a neoprene cup manufactured with a bushing to prevent short-circuiting of the hanger rod as it passes through the hanger housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Provide "RMXA" by M. W. Sausse & Co., Inc., or equal.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant neoprene minimum 1/4 inch thick and maximum 50 durometer. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame designed to properly distribute the spring load on the neoprene and prevent its crushing.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Spring Hanger H3: Pre-compressed Spring Hanger delivered pre-compressed to their planned installed deflection to keep pipes or equipment steady during installation. Hangers shall be designed with a slow-release mechanism to free the spring after installation is complete and the spring is fully loaded. Vibration isolation hangers shall contain a laterally-stable steel spring set in a neoprene cup manufactured with a bushing to prevent short-circuiting of the hanger rod as it passes through the hanger housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Great care shall be taken to see that all springs are free to oscillate 0.25". Deflection shall be clearly indicated by means of a scale. Provide "RMXA-PC" by M. W, Sausse & Co., Inc., or equal.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant neoprene minimum 1/4 inch thick and maximum 50 durometer. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame designed to properly distribute the spring load on the neoprene and prevent its crushing.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

L. Spring Hangers with Vertical-Limit Stop H3: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop. Provide “HXA” by M.W. Sausse & Co., Inc., or equal.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

M. Piping Isolation Materials
   1. Flexible Pipe Connectors FPC: Flexible pipe connectors shall be fabricated of multiple plies of nylon cord, fabric, and neoprene, vulcanized so as to become inseparable and homogeneous. Straight connectors shall be formed into a double sphere shape. Elbow connectors shall have a single sphere shape at the curve of the unit. Flexible connectors shall be able to accept compressive, elongating, transverse, and angular movements. Flexible connectors shall be selected and specially outfitted if necessary to suit the system temperature, pressure, and fluid type. Connectors for pipe sizes 2 inches and smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings. Control cables shall be provided if required. Provide "MFDEJ" or “SFDEJ" by Mason or equal.

2. Pipe Riser Resilient Support RPAG: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Maximum neoprene durometer 50. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
3. Resilient Pipe Sleeves RPS1: Resilient Pipe Sleeve at Support or Construction Penetration: Sleeve shall consist of a formed and stiffened galvanized steel sleeve lined on the inside with moisture and vermin resistant felt bonded to the metal sleeve and 1/2-inch thick. Sleeve inside diameter shall equal pipe outside diameter in each application. Sleeve shall be split longitudinally so it can be snapped over pipes and reclosed without damage. Sleeve lengths shall be as recommended by the manufacturer for the given diameters, but shall not be less than 3 inches. Provide "PR-Isolator" by Porter-Roemer, "Trisolator" by Stoneman Engineering or approved equal.
4. Resilient Pipe Sleeves RPS2: Resilient Pipe Sleeve at Construction Penetration: This unit shall consist of two bolted pipe halves with 3/4 inch or thicker neoprene sponge bonded to the inner faces. The seal shall be tightenable around the pipe to eliminate clearance between the inner sponge face and the piping. Sleeve shall be 2 inches longer than the thickness of the construction it penetrates. Where pipe temperatures exceed 240 degrees F, use 10-pcf-density glass fiber insulation in lieu of sponge neoprene. Provide "SWS" by Mason, "PS-1-D" by Kinetics or equal.

2.2 FLEXIBLE DUCT CONNECTORS

A. Flexible duct connectors shall be woven fiber-glass fabric material with a minimum weight of 24 oz./sq. yd. Connectors shall be minimum of 4-inches long and allow 1-inch of slack at connections. Flexible duct connectors shall have metal collar frames at each end of connections. Flexible Duct Connectors shall be Duro Dyne Durolon or equal.

2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS (TYPE C1)

A. Basis-of-Design Product: Subject to compliance with requirements, provide M.W. Saussé & Co., Inc., or a comparable product by one of the following:
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.
   3. Mason Industries.
   4. Or equal.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
   1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.
      a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
      b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
      c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
      d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4-inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials. Provision shall be made for access ports with waterproof covers at the spring location and 2-inch thermal insulation on the sides of the lower curb.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Basis-of-Design Product: Subject to compliance with requirements, provide M.W. Saussé & Co., Inc., (Vibrex) or a comparable product by one of the following:
   1. Amber/Booth Company, Inc.
   2. Kinetics Noise Control.
   3. Mason Industries.
   4. Or equal.

B. Base BS1: No Frame Required for Floor Mounting: This base mounting method shall be used only with small pieces of equipment that have an integral casing or base frame that is adequately strong to be supported directly on vibration isolators without deforming the casing or frame or affecting equipment or isolator operation to any significant or noticeable extent. Place vibration isolators directly under equipment or connect steel height-saving brackets to the sides of the equipment and place isolators under brackets. Equipment manufacturer shall approve such mounting.

C. Steel Base BS2: Factory-fabricated, welded, structural-steel bases and rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Frames may be rectangular or tee-shaped in plan. The depth of steel frame base members shall be minimum one-tenth the longest dimension of the base. Frame bases shall include side-mounting height-saving brackets for attachment to vibration isolators. Provide "RMSB or RMUAB" by M. W. Sausse & Co., Inc. or equal.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Inertia Base BS3: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete. Concrete inertia bases for floor-mounted equipment shall be formed of stone-aggregate concrete (150 lb/cu ft) and appropriate steel reinforcing cast between perimeter structural steel sections. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete shall be provided and poured by the Contractor on site Inertia bases shall be built to form a rigid base that will not twist, rack, deform, deflect, or crack in any manner. Provide "Custom" RMSBI" by M. W. Sausse & Co., Inc., or equal.
   1. Design Requirements: Lowest possible mounting height with not less than 2-inch or 3 percent of the shorter base dimension, whichever is greater clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   2. Include supports for suction and discharge elbows for pumps.
   3. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   4. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
   5. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 SEISMIC-RESTRAINT DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide M.W. Saussé & Co., Inc., or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries
3. Hilti, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Unistrut; Tyco International, Ltd.
7. Or equal.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
3. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
5. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
7. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
8. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
9. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

C. Type I, Equipment Not Vibration Isolated

1. Attach to the structure in accordance with the Paragraph 2.5.B.

D. Type II, Vibration Isolated Equipment

1. Mount all vibration isolated equipment on rigid steel frames as described in the vibration control specifications unless the equipment manufacturer certifies direct attachment capability.
2. Each isolated frame shall have a minimum of four all directional seismic snubbers located as close to the vibration isolators as possible.
3. The snubber shall consist of interlocking steel members restrained by snubbing material made of bridge bearing neoprene.
4. The snubbers shall contain an elastomeric neoprene one-piece bushing that is replaceable and a minimum of 1/4 inch thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 inch or more than 1/4 inch. The neoprene bushing shall be capable of rotation to verify that no short circuiting of the vibration isolator exists. Shim snubbers as required to maintain clearances.
5. The snubber end cap shall be removable for inspection of snubber internal clearances.

E. Type III, Seismic Restraint of Suspended Piping

1. Support all piping and ductwork systems per SMACNA "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems" and 2013 California Building Code.
2. Provide restraints for all trapeze mounted piping where the total supported weight is greater than or equal to a 2-1/2 inch pipe, except in equipment rooms where all trapeze mounted piping weight is greater or equal to 1-1/4 inch pipe.
3. Provide restraints for all piping 1-1/4 inch and larger located in boiler rooms, mechanical equipment rooms and refrigeration machinery rooms.
4. Provide restraints for all fuel gas and oil piping, medical gas piping and compressed air piping 1 inch and larger.
5. Cable shall be installed with sufficient slack to avoid short circuiting the vibration isolation.

F. Type IV, Suspended Equipment
1. Utilize a slack cable restraint system.
2. Cables shall be installed with sufficient slack to avoid short circuiting the vibration isolation.

2.6 THRUST RESTRAINT MATERIALS

A. Restraint TR1: Neoprene Restraint: Thrust restraint shall be custom fabricated using a Type B1 neoprene-in-shear isolator and a steel angle. Neoprene isolator bolted to one angle leg opposes equipment thrust; second angle leg bolted to appropriate structure. The steel angle shall be sufficiently rigid and the mounting sufficiently sized and secure to resist the lateral movement of equipment during on-off cycle.

B. Restraint TR2: Steel Spring Restraint: Thrust restraint shall consist of a spring element in series with a neoprene cup. The unit shall be designed to have the same deflection as specified for the base mountings or hangers supporting the equipment. The spring element shall be adjusted in the field to allow for a maximum of 1/4-inch movement during starting or stopping of the equipment. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor. Provide "RMXA" by M.W. Sausse & Co., Inc., or equal.

2.7 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

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

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

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

B. Piping Restraints

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

C. Piping Isolation

1. Provide piping isolation as indicated in specification or as noted on drawings.
2. Unless otherwise specified, provide resilient support for all HVAC pipes throughout the building. No such piping is to come into rigid contact with the building.
3. Support all piping in mechanical equipment rooms on Type H2 or H3 springs sized for minimum 1-inch static deflection, unless otherwise noted.
4. Support on vibration isolators all piping outside of mechanical equipment rooms which is connected to and within a 30-foot radius of a vibration-isolated piece of equipment. If the piece of equipment is supported on neoprene isolators, support pipes on Type B1 or H1 isolators sized for minimum 0.35-inch deflection. If the piece of equipment is supported on spring isolators, support pipes on Type B2 or H2 or H3 springs sized for minimum 1-inch deflection.
5. Throughout the rest of the building not covered in Paragraph 3 or 4 above, use RPS1 resilient pipe sleeves for support. An alternate to this is 1-inch-thick, 10 pcf-density glass fiber pipe insulation with suitable bearing plates to prevent crushing of insulation and without any steel pin or other rigid connection from plate to pipe through insulation.

D. Installation of Resilient Pipe Supports

1. Provide Type RPS1 or RPS2 or Custom resilient pipe sleeves wherever pipes penetrate construction.
2. Provide Type RPAG resilient pipe anchor/guide where anchors and / or guides are required in horizontal and vertical piping. Connect RPAG units to heavy structure only.
3. Release restraining washers and nuts in order to "free" all pre-compressed spring hangers.

E. Installation of Floor and Rooftop Mounted Equipment

1. Unless otherwise shown or specified, all base-mounted equipment shall be set on 4-inch thick, hardrock concrete housekeeping pads. Vibration isolators and seismic restraints shall be bolted to the housekeeping pad. The pad dimensions shall exceed the equipment footprint (including floor mounts) by at least 24" in each direction (i.e. 12 inches per side).
2. Unless otherwise indicated, a minimum clearance of 1 inch shall be provided between the top of a housekeeping pad or floor or roof and the underside of an equipment unit or steel base frame that is vibration-isolated. The minimum clearance where a concrete inertia block is used shall be 2 inches or 3 percent of the base's smaller dimension, whichever is larger. This space shall be cleaned thoroughly of all dirt and debris.
3. For isolation equipment (Mounts S1 and RS1) with neoprene pads bearing directly on structure, fasten the isolator base plates to the building structure with suitable bolts. Isolate steel bolts from steel base plates with neoprene bushings or washers and sleeves (Mount Type P3) minimum 1/4 inch thick and maximum 40 durometer hardness. Provide steel washers to distribute bolt head loads to neoprene bushings or washers below. Size bolt holes in isolator bases to account for neoprene bushings or sleeves.

4. All bases for pumps shall be of sufficient area to support any required pipe stanchions below pipe elbows.
5. Bases for boilers shall be of sufficient area to support draft fans, if included.
6. Fans and pumps and their respective motors shall always be mounted on a common base.
7. Cooling towers: seismic restraints shall be provided between the grillage and dunnage steel or structure. Seismic restraints shall be installed and adjusted after isolators have been adjusted. Chillers shall be treated similarly.
8. Wind loads shall be accounted for in rooftop installations, including appropriate snubbers and slack-cable restraints.
9. Vibration isolation curbs shall be made weathertight by sealing with flexible aluminum flashing or closed-cell neoprene or flexible vinyl all around the periphery. This weatherproofing shall in no way inhibit the vibration isolation of the spring elements. A closed-cell sponge gasket shall be provided between the equipment unit and the curb to form a weathertight seal.

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

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

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

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

L. Installation of Thrust Restraints: Provide horizontal thrust restraints as scheduled for fans delivering large air quantities and with a tendency to rock back on their spring mounts. Install thrust restraints parallel to the axis of air delivery and in pairs on opposite sides of the fan.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 – HYDRONIC PIPING for piping flexible connections.

3.5 FIELD QUALITY CONTROL

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

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. HVAC Piping Vibration Isolation Schedule

Description	Design Deflection	Isolator	Seismic Restraint
		Type	Type
Main Horizontal Runs	N/A	RPS1	III
Suspended within Mechanical Room	1.0”	H3	III
Located within 30’ radius of vibrating equipment with type H1 hanger	N/A	B1 or H1	III
Located within 30’ radius of vibrating equipment with type H2 or H3 hanger	1.0”	B2, H2 or H3	III
Floor Supported	1.0”	S1	-
Main Vertical Risers	N/A	RPAG	N/A
Support at Roof Level	1.0”	-	
All connections to pumps	N/A	FPC	N/A

1. Type P2 pad to be located between chilled water supply and return pipes and support stand.

B. HVAC Equipment Vibration Isolation Schedule

Equipment Mark	Design Deflection	Isolator	Frame	Seismic Restraint
		Type	Type	Type
Pumps	2.0”	RS1	BS2	II
Air Handling Unit	2.0”	RS1	-	II
Fans (5hp and below, 750RPM and above)	1.0”	RS1	BS2	II

1. Frame may be omitted if a written undertaking can be obtained from equipment manufacturer, stating that factory-supplied frame will be suitable for isolator point-loading and will be adequate seismically, per local Code requirements.
2. Where type RS1 spring mounts with vertical travel limit stops are specified, seismic snubbers may be omitted if a Licensed Structural Engineer verifies that limit stop on RS1 mount will provide sufficient seismic restraint to conform with local Code requirements.

3. Provide seismic restraint calculations for all connections of equipment to support structure.
4. Thrust restraints (TR-2) providing 1-inch deflection shall be installed on equipment when the air thrust is greater than 10 percent of the equipment weight.
5. Supply fans in air handling units (AHU) shall be vibration isolated within the fan enclosures with 2.0” minimum static deflection unless noted otherwise.
6. For all other equipment refer to details on M6.xx Series Drawings.

END OF SECTION

SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Equipment Labels
   2. Warning Signs and Labels
   3. Pipe Labels
   4. Duct Labels
   5. Stencils
   6. Valve Tags
   7. Warning Tags

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals including valve tag number, location, function, and valve manufacturer's name and model number.

F. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 COORDINATION

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

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

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Product: Provide product by one of the following:
   1. Seton.
   2. Brady.
   3. Or equal.

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment

1. Material and Thickness: Stainless Steel, 0.025-inchminimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4-inch.
5. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless-steel rivets.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's unique equipment number.

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

2.3 WARNING SIGNS AND LABELS

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

B. Letter Color: Black.

C. Background Color: Yellow.

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

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

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

G. Fasteners: Stainless-steel rivets.

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

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

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, showing flow direction and meeting the requirements of ASME (ANSI) Std. A13.1-2007.

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

C. Strap-on Pipe Labels: Semirigid plastic formed to partial cover circumference of pipe and to attach to pipe with plastic straps.

D. Markers for underground mechanical and plumbing piping: 6 mm thick, 3” wide, fluorescent yellow polyethylene tape with imprint to read “Caution – Buried Pipe Below”.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size
   a. Pipes O.D. (incl. insulation) 1-3/8” ” and smaller: At least 1/2 inches high.
   b. Pipes O.D. (incl. insulation) greater than 1-3/8” but less than or equal to 2-3/8 inches: at least 3/4-inch

c. Pipes O.D. (incl. insulation) greater than 2-3/8 inches: at least 1-1/4 inches.

2.5 DUCT LABELS

A. Self-Adhesive duct Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

C. Letter Color: White.

D. Background Color
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

E. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.

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

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

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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.6 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Aluminum.
   2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

B. Letter Color: White.

C. Background Color:
   1. Blue: For cold air supply ducts.
   2. Yellow: For hot air supply ducts.
   3. Green: For outside, exhaust, relief, return or mixed air ducts.

2.7 VALVE TAGS

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

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

2. Piping diagram showing valving requirement and corresponding valve tags to be included in operation and maintenance data.

2.8 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Reinforced grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.1 PREPARATION

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

B. Install identification after insulation and painting of materials is completed.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each item of mechanical equipment and control panels.

B. Locate equipment labels where accessible and visible.

C. Equipment out of view behind access doors in unfinished rooms shall also be identified on the face of the access door.

D. Provide metal labels for outdoor and indoor equipment.

3.3 PIPE LABEL INSTALLATION

A. Pipe sizes (incl. insulation) < 3/4-inch O.D.: Brass Tag Makers

B. Pipe sizes (incl. insulation) 3/4-inch through 5-7/8-inch O.D.: Pre-tensioned Pipe labels

C. Pipes Sizes (incl. insulation) 6 inches and greater: Strap-on pipe labels.

D. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

E. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

F. Pipe Label Color Schedule:
   1. Chilled Water Piping: White letters on a safety green background.
   2. Heating Hot water: White letters on a safety green background.
   3. Refrigerant Piping: Black letters on a safety orange background.
   4. Natural Gas Piping: Black letters on a safety yellow background.

3.4 DUCT LABEL INSTALLATION

A. Concealed and exposed insulated indoor ductwork: Self-adhesive duct labels.

B. Exposed to conditioned space and un-insulated indoor ductwork: Stenciled duct label.

C. Exposed with field applied woven glass-fiber fabric jacket: Stenciled duct label.

D. Concealed, outdoor ductwork: Self-adhesive duct labels

E. Exposed, outdoor ductwork: Stenciled duct label.

F. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections. List tagged valves in a valve schedule.

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

1. Valve-Tag Size and Shape: 1-1/2 inches, round.
2. Valve-Tag Color:
   a. Chilled Water: Green.
   b. Heating Hot Water: Green.
   c. Refrigerant: Orange.
   d. Gas: Yellow.
3. Letter Color: Black.

3.6 STICK ON DOTS

A. Provide stick on dots on ceiling to locate equipment above T-bar type panel ceiling. Locate in corner of panel closest to equipment. Dots shall be blue for HVAC dampers, valves and terminal boxes, green for plumbing and red for controls.

3.7 WARNING-TAG INSTALLATION

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

3.8 VOLUME DAMPER

A. Provide volume dampers with temporary red ribbons attached to the valve and freely hanging to assist Owner Representative to verify installation during site observations and ease locating dampers by TAB contractor.

END OF SECTION

SECTION 230593
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Balancing Air Systems
      a. Constant-air volume systems.
      b. Variable-air-volume systems.
   2. Balancing Hydronic Piping Systems
      a. Constant-flow hydronic systems.
      b. Variable-flow hydronic systems.
   3. Sound measurement of equipment operating conditions.
   4. Vibration measurement of equipment operating conditions.
   5. Domestic Hot Water System

B. See Commissioning Requirements Section 019113.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council

B. TAB: Testing, Adjusting, and Balancing

C. TABB: Testing, Adjusting, and Balancing Bureau

D. TAB Contractor: An entity engaged to perform TAB Work

1.3 ACTION SUBMITTALS

A. LEED Submittals
   1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
   2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

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

B. Contract Documents Examination Report: Within 30 days of Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC as a TAB technician.

B. TAB Conference: Meet with Owner’s Representative on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Allow for seven days advance notice of scheduled meeting time and location.

1. Agenda Items
   a. The Contract Documents examination report.
   b. The TAB plan.
   c. Coordination and cooperation of trades and subcontractors.
   d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Owner’s Representative.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

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

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Allow for seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 PRODUCTS

2.1 NOT USED

PART 3 EXECUTION

3.0 PREPARATION

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

B. Install identification after insulation and painting of materials is completed.

3.1 EXAMINATION

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

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

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

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

E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 METAL DUCTS and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan curves.

   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

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

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

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

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

K. Provide a written report to CxA or Construction Manager for deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Submit written report to CxA or Construction Manager. Verify the following:

   1. Permanent electrical-power wiring is complete.
   2. Automatic temperature-control systems are operational.
   3. Equipment and duct access doors are securely closed.
   4. Balance, smoke, and fire dampers are open.
   5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   6. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing, adjusting and balancing procedures on each system after leakage and pressure tests on air and water distribution systems have been satisfactorily completed. HVAC systems testing and balancing shall be in accordance with the following:

   1. AABC's "National Standards for Testing and Balancing Heating, Ventilating and Air conditiong System", latest edition.
   2. ASHRAE HVAC Applications Manual, 2007, Chapter 37 Testing, Adjusting and Balancing.
   3. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "AIR DUCT ACCESSORIES."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230700 "HVAC INSULATION."

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

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

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

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

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 233113 "METAL DUCTS."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
2. Measure fan static pressures as follows to determine actual static pressure:
    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
    a. Report the cleanliness status of filters and the time static pressures are measured.
4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Owner’s Representative for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure airflow of submain and branch ducts.
      a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
   3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-VOLUME AIR SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   3. Measure total system airflow. Adjust to within indicated airflow.
   4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
   5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
      a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
   6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
      a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.7 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.8 GENERAL 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 the 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 makeup water-station pressure gage for adequate pressure for highest vent.
   3. Check flow-control valves for specified sequence of operation, and set at indicated flow.
   4. 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.
   5. Set system controls so automatic valves are wide open to heat exchangers.
   6. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
   7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure 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. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
      a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Owner’s Representative and comply with requirements in Section 232123, HYDRONIC PUMPS.
   2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
      a. Monitor motor performance during procedures and do not operate motors in overload conditions.
   3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on 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 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated pre-settings.

E. 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.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

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

3.11 PROCEDURE FOR SOUND LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches above the floor and at least 36 inches from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

3.12 PROCEDURE FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria

1. Solid-state circuitry with a piezoelectric accelerometer.

2. Velocity range of 0.1 to 10 inches per second.
3. Displacement range of 1 to 100 mils.
4. Frequency range of at least 0 to 1000 Hz.
5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.
   1. Use a calibrator provided with the vibration meter.
   2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
   1. Turn off equipment in the building that might interfere with testing.
   2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp.

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
   1. Fans and HVAC Equipment with Fans
      a. Fan Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
   2. Equipment Base: Top and side.
      a. Building: Floor.
      b. Ductwork: To and from equipment after flexible connections.
      c. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.
   1. Verify that vibration isolation is installed in the required locations.
   2. Verify that installation is level and plumb.
   3. Verify that isolators are properly anchored.
   4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
   5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.13 PROCEDURE FOR DOMESTIC HOT WATER SYSTEM

A. Refer to P0.01, CALGREEN Notes for Testing and Adjusting of Water Heating System.

3.14 TOLERANCES

A. Set HVAC system's air flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
   2. General Air Outlets and Inlets: Plus or minus 10 percent.
   3. Laboratory Air Outlets and Inlets: Plus or minus 5 percent.
   4. Heating-Water Flow Rate: Plus or minus 5 percent.
   5. Chilled-Water Flow Rate: Plus or minus 5 percent.
   6. Domestic Hot Water System Flow Rate: Plus or minus 5 percent.

3.15 REPORTING

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

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

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

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

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

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

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

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
12. Description of system operation sequence if it varies from the Contract Documents.
13. Nomenclature sheets for each item of equipment.
14. Data for terminal units, including manufacturer's name, type, size, and fittings.
15. Notes to explain why certain final data in the body of reports vary from indicated values.
16. Test conditions for fans performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, 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.
6. Balancing stations.
7. Position of balancing devices.

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

1. Unit Data
   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches, and bore.
   i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   j. Number, make, and size of belts.
   k. Number, type, and size of filters.
2. Motor Data
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values)
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Heating-coil static-pressure differential in inches wg.
   g. Outdoor airflow in cfm).
   h. Outdoor-air damper position.

F. Apparatus-Coil Test Reports

1. Coil Data
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values)
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Entering-air, wet- and dry-bulb temperatures in deg F.
   f. Leaving-air, wet- and dry-bulb temperatures in deg F.

G. Fan Test Reports: For supply and exhaust fans, include the following:

1. Fan Data
   a. System identification.
   b. Location.
   c. Make and type.

d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Motor Data
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values)
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data
   a. System and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft.
   g. Indicated air flow rate in cfm.
   h. Indicated velocity in fpm.
   i. Actual air flow rate in cfm.
   j. Actual average velocity in fpm.
   k. Barometric pressure in psig.

I. Air-Terminal-Device Reports

1. Unit Data
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Apparatus used for test.
   d. Area served.
   e. Make.
   f. Number from system diagram.
   g. Type and model number.
   h. Size.
   i. Effective area in sq. ft.
2. Test Data (Indicated and Actual Values)
   a. Air flow rate in cfm.
   b. Air velocity in fpm.
   c. Preliminary air flow rate as needed in cfm.
   d. Preliminary velocity as needed in fpm.
   e. Final air flow rate in cfm.
   f. Final velocity in fpm.
   g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data
   a. System and air-handling-unit identification.
   b. Location and zone.
   c. Room or riser served.

d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values)
   a. Air flow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
   1. Unit Data
      a. Unit identification.
      b. Location.
      c. Service.
      d. Make and size.
      e. Model number and serial number.
      f. Water flow rate in gpm.
      g. Water pressure differential in feet of head or psig.
      h. Required net positive suction head in feet of head or psig.
      i. Pump rpm.
      j. Impeller diameter in inches.
      k. Motor make and frame size.
      l. Motor horsepower and rpm.
      m. Voltage at each connection.
      n. Amperage for each phase.
      o. Full-load amperage and service factor.
      p. Seal type.
   2. Test Data (Indicated and Actual Values)
      a. Static head in feet of head or psig.
      b. Pump shutoff pressure in feet of head or psig.
      c. Actual impeller size in inches.
      d. Full-open flow rate in gpm.
      e. Full-open pressure in feet of head or psig.
      f. Final discharge pressure in feet of head or psig.
      g. Final suction pressure in feet of head or psig.
      h. Final total pressure in feet of head or psig.
      i. Final water flow rate in gpm.
      j. Voltage at each connection.
      k. Amperage for each phase.

L. Instrument Calibration Reports
   1. Report Data
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

M. Vibration Measurement Reports
   1. Date and time of test.
   2. Vibration meter manufacturer, model number, and serial number.
   3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
   4. Diagram of equipment showing the vibration measurement locations.
   5. Measurement readings for each measurement location.
   6. Calculate isolator efficiency using measurements taken.
   7. Description of predominant vibration source.

N. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms

1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

3.17 INSPECTIONS

A. Initial Inspection

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
   a. Measure airflow of at least 20 percent of air outlets.
   b. Measure water flow of at least 10 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Verify that balancing devices are marked with final balance position.
   e. Note deviations from the Contract Documents in the final report.

B. Final Inspection

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner’s Representative.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Owner’s Representative.
3. Owner’s Representative shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

D. Prepare test and inspection reports.

E. After report is submitted, the TAB contractor's test and balance engineer shall conduct TAB verification up to 20% of test values with the CxA.

3.18 ADDITIONAL TESTS

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

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

END OF SECTION

SECTION 230700
HVAC INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return.
   4. Indoor, exposed return.
   5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   7. Outdoor, concealed return air.
   8. Outdoor, exposed return air.
   9. Outdoor, concealed supply and outdoor air.
   10. Outdoor, exposed supply and outdoor air.

B. Section includes insulating the following HVAC piping systems:
   1. Condensate drain piping.
   2. Chilled water piping.
   3. Heating hot-water piping.
   4. Refrigerant piping.

C. Section Includes
   1. Insulation Materials
      a. Flexible elastomeric.
      b. Cellular Glass.
      c. Mineral fiber.
   2. Insulating cements.
   3. Adhesives.
   4. Mastics.
   5. Lagging adhesives.
   6. Sealants.
   7. Factory-applied jackets.
   8. Field-applied fabric-reinforcing mesh.
   9. Field-applied cloths.
   10. Field-applied jackets.
   11. Tapes.
   12. Securements.
   13. Corner angles.

D. Related Sections
   1. Division 22 Section "Plumbing Insulation."
   2. Division 23 Section "Metal Ducts" for duct liners.

E. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals

1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.
2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
3. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings

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

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: Installing Company shall be specializing in performing the work of this section with minimum five years experience.

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

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to Owner's Representative. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Section 230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.

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

1.7 SCHEDULING

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

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

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

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

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

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

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

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

1. Manufacturers: Provide one of the following:
   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
   d. Or equal.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Provide one of the following:
   a. Pittsburgh Corning Corporation; Foamglas.
   b. Or equal.
2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

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

1. Manufacturers: Provide one of the following:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite EQ FSK.
   c. Knauf Insulation; Duct Wrap.
   d. Owens Corning; All-Service Duct Wrap.
   e. Or equal.

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

1. Manufacturers: Provide one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Johns Manville; 800 Series Spin-Glas.
   c. Knauf Insulation; Insulation Board.

d. Owens Corning; Fiberglas 700 Series.
e. Or equal.

I. Mineral-Fiber, Pre-formed Pipe Insulation
1. Manufacturers: Provide one of the following:
a. Johns Manville; Micro-Lok.
b. Knauf Insulation; 1000 Pipe Insulation.
c. Owens Corning; Fiberglas Pipe Insulation.
d. CertainTeed Corp.
e. Or equal.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Provide one of the following:
a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Owens Corning; Fiberglas Pipe and Tank Insulation.
e. Or equal.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
1. Products: Provide one of the following:
a. Ramco Insulation, Inc.; Super-Stik.
b. Or equal.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
1. Products: Provide one of the following:
a. Ramco Insulation, Inc.; Super-Stik.
b. Or equal.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
1. Products: Provide one of the following :
a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.
b. Or equal.

2.3 ADHESIVES

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

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

C. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
1. Manufacturers: Provide one of the following:
a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.
c. Or equal

E. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Manufacturers: Provide one of the following:
      a. Aeroflex USA Inc.; Aeroseal.
      b. Armacell LCC; 520 Adhesive.
      c. RBX Corporation; Rubatex Contact Adhesive.
      d. Or equal.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Manufacturers: Provide one of the following:
      a. Childers CP-127.
      b. Foster Products Corporation, H. B. Fuller Company; 85-60/85-70.
      c. ITW TACC, Division of Illinois Tool Works; S-90/80.
      d. Marathon Industries, Inc.; 225.
      e. Mon-Eco Industries, Inc.; 22-25.
      f. Or equal.
   2. Adhesive shall comply with California Dept of Public Health (CDPH) Standard Method Ver. 1.1, 2010 Small Scale Environmental Chamber Test for VOCs. for CA Specification 01350

G. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Manufacturers: Provide one of the following:
      a. Childers Products, Division of ITW; CP-127.
      b. Foster Products Corporation, H. B. Fuller Company; 85-60/85-70.
      c. ITW TACC, Division of Illinois Tool Works; S-90/80.
      d. Marathon Industries, Inc.; 225.
      e. Mon-Eco Industries, Inc.; 22-25.
      f. Or equal.

H. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Manufacturers: Provide one of the following:
      a. Dow Chemical Company (The); 739, Dow Silicone.
      b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
      c. P.I.C. Plastics, Inc.; Welding Adhesive.
      d. Red Devil, Inc.; Celulon Ultra Clear.
      e. Speedline Corporation; Speedline Vinyl Adhesive.
      f. Or equal.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II and be QPL/QPD Listed.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Manufacturers: Provide one of the following:
      a. Childers ; CP-38.
      b. Foster , H. B. Fuller Company; 30-80.
      c. Marathon Industries, Inc.; 590.
      d. Mon-Eco Industries, Inc.; 55-40.
      e. Vimasco Corporation; 749.
      f. Or equal.
   2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
   5. Color: White.

2.5 LAGGING ADHESIVES

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

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Provide one of the following:
    a. Childers ; CP-50AHV2.
    b. Foster , H. B. Fuller Company; 30-36.
    c. Marathon Industries, Inc.; 130.
    d. Mon-Eco Industries, Inc.; 11-30.
    e. Vimasco Corporation; 136.
    f. Or equal.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants
1. Joint Sealants for Cellular-Glass, Phenolic and polyisocyanurate.
2. Manufacturers: Provide one of the following:
    a. Childers ; CP-76/CP-70.
    b. Foster , H. B. Fuller Company; 30-45/95-50.
    c. Marathon Industries, Inc.; 405.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Pittsburgh Corning Corporation; Pittseal 444.
    f. Vimasco Corporation; 750.
    g. Or equal.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants
1. Manufacturers: Provide one of the following:
    a. Childers ; CP-70/CP-76.
    b. Foster , H. B. Fuller Company; 30-45/95-44.
    c. Marathon Industries, Inc.; 405.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Vimasco Corporation; 750.
    f. Or equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, and PVC Jacket Flashing Sealants
1. Manufacturers: Provide one of the following:
    a. Childers ; CP-70/CP-76.
    b. Foster , H. B. Fuller Company; 30-45/95-44.
    c. Marathon Industries, Inc.; 405.
    d. Mon-Eco Industries, Inc.; 44-05.

    e. Vimasco Corporation; 750.
    f. Or equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
   1. Manufacturers: Provide one of the following:
      a. Childers ; Chil-Glas No. 10.
      b. Vimasco Corporation; Elastafab 894.
      c. Or equal.

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 4 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
   1. Manufacturers: Provide one of the following:
      a. Childers ; Chil-Glas No. 5.
      b. Or equal.

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.
   1. Manufacturers: Provide one of the following:
      a. Foster , H. B. Fuller Company; Mast-A-Fab.
      b. Vimasco Corporation; Elastafab 894.
      c. Or equal.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
   1. Manufacturers: Provide one of the following:
      a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
      b. Or equal.

2.10 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Manufacturers: Provide one of the following:
      a. Johns Manville; Zeston.
      b. P.I.C. Plastics, Inc.; FG Series.
      c. Proto PVC Corporation; LoSmoke.
      d. Speedline Corporation; SmokeSafe.
      e. Or equal.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White.
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket
   1. Manufacturers: Provide one of the following:
      a. Childers Products, Division of ITW; Metal Jacketing Systems.
      b. PABCO Metals Corporation; Surefit.
      c. RPR Products, Inc.; Insul-Mate.
      d. Or equal.
   2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
      a. Factory cut and rolled to size.
      b. Material, finish, and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Manufacturers: Provide one of the following:
   a. Pittsburgh Corning Corporation; Pittwrap.
   b. Polyguard; Insulrap No Torch 125.
   c. Or equal.

F. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.
   1. Manufacturers: Provide one of the following:
      a. Polyguard; Alumaguard 60.
      b. Or equal.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Manufacturers: Provide one of the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
      b. Compac Corp.; 104 and 105.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
      e. Or equal.
   2. Width: 3 inches.
   3. Thickness: 11.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Manufacturers: Provide one of the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      b. Compac Corp.; 110 and 111.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
      d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
      e. Or equal.
   2. Width: 3 inches.
   3. Thickness: 6.5 mils.
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Manufacturers: Provide one of the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
      b. Compac Corp.; 130.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
      d. Venture Tape; 1506 CW NS.
      e. Or equal.
   2. Width: 2 inches.
   3. Thickness: 6 mils.
   4. Adhesion: 64 ounces force/inch in width.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Manufacturers: Provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
b. Compac Corp.; 120.
c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
d. Venture Tape; 3520 CW.
e. Or equal.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands
1. Manufacturers: Provide one of the following:
a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.
d. Or equal.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, diameter shank, length to suit depth of insulation indicated.
a. Manufacturers: Provide one of the following:
1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.
2. Or equal.
3. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
a. Manufacturers: Provide one of the following:
1) AGM Industries, Inc.; CWP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.
5) Or equal.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
a. Manufacturers: Provide one of the following:
1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.
5) Or equal.
b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
a. Manufacturers: Provide one of the following:
1) GEMCO.
2) Midwest Fasteners, Inc.
3) Or equal.

C. Wire: 0.062-inch soft-annealed, galvanized steel.
   1. Manufacturers: Provide one of the following:
      a. C & F Wire.
      b. Childers Products.
      c. PABCO Metals Corporation.
      d. RPR Products, Inc.
      e. Or equal.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

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

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

PART 3 EXECUTION

3.1 PREPARATION

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

B. Install identification after insulation and painting of materials is completed.

3.2 EXAMINATION

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

3.3 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

3.4 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

L. Install insulation with factory-applied jackets as follows
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

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

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

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

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

3.5 PENETRATIONS

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

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in 078400 "FIRE SAFING – FIRE STOPPING" and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in 078400 "FIRE SAFING – FIRE STOPPING."

3.6 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation. <u>Compressed blanket insulation over elbow fitting or bends is not acceptable.</u>
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive. <u>Compressed blanket insulation over tee fitting is not acceptable.</u>
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

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

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

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

3.7 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

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

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

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

3.9 MINERAL-FIBER INSULATION INSTALLATION

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

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

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

D. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

E. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions, adhesive can be omitted from top surface of horizontal rectangular ducts.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints. Longitudinal joints shall be located on underside of pipe and ducts.

3.11 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coat over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   a. Finish Coat Material: Interior, flat, latex-emulsion size.
2. PVC jackets shall not be painted.

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

C. Color: Final color as selected by Owner’s Representative. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner reserves the right to engage at Owner’s expense a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections

1. Inspect ductwork, randomly selected by Owner’s Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
2. Inspect field-insulated equipment, randomly selected by Owner’s Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by Owner’s Representative, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three Insert number locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.13 EQUIPMENT INSULATION SCHEDULE

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

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

C. Heating-hot-water pump insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

D. Heating-hot-water expansion tank insulation shall be the following:

1. Mineral-Fiber Board: 2 inch thick and 3-lb/cu. ft. nominal density.

E. Heating-hot-water air-separator insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.14 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return.
4. Indoor, exposed return.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness per Applicable Code Requirements and ASHRAE/IESNA 90.1-2007.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.
8. Ducts Exposed in conditioned space served by the duct system exposed to the space.

3.15 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

B. Concealed, supply and return -air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

C. Exposed, in conditioned space not supplied by duct system, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

D. Exposed in mechanical rooms, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

E. Exposed in mechanical rooms, supply and return -air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Exposed in unconditioned spaces, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

G. Exposed in unconditioned spaces, supply and return -air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

H. Concealed, rectangular, round and flat-oval, outside air-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

I. Concealed, outside-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

J. Exposed, rectangular, round and flat-oval, outside air-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

K. Exposed, outside-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3/4-lb/cu. ft. nominal density.

L. Exposed in mechanical rooms, rectangular, round and flat-oval, outside -air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed in mechanical rooms, outside -air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.16 OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

B. Concealed, supply and return -air plenum insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

C. Exposed, rectangular, round and flat-oval, supply and return -air duct insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

D. Exposed, supply and return -air plenum insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

E. Concealed, rectangular, round and flat-oval, outside air duct insulation shall be the following:

1. Internally lined: 2 inches thick, refer to section 233113.2.2.

F. Concealed, outside-air plenum insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

G. Exposed, rectangular, round and flat-oval, outside -air duct insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

H. Exposed, outside -air plenum insulation shall be the following:
   1. Internally lined: 2 inches thick, refer to section 233113.2.2.

3.17 PIPING INSULATION SCHEDULE, GENERAL

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

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

3.18 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Degrees F
   1. All Pipe Sizes: Insulation shall be one of the following with vapor barrier:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.

B. Chilled Water Supply and Return
   1. NPS 2 and Smaller: Insulation shall be the following with vapor barrier:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   2. NPS 2 and Smaller, 3' or less from coil connection and where physical constraints do not permit insulation listed in the paragraph above cannot be installed:
      a. Flexible Elastomeric: 1 inch thick.
   3. NPS 2-1/2 and Larger: Insulation shall be the following with vapor barrier:
      a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

C. Heating Hot-Water Supply and Return
   1. Branches to terminal boxes and reheat coils less than 3 feet in length from main to box, NPS 2 and Smaller: Insulation shall be the following:
      a. Flexible Elastomeric, Type I: 1 inch thick.
   2. NPS 2 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
   3. NPS 2-1/2 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

D. Hot Service Drains
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Calcium Silicate: 1-1/2 inches thick.
      b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

E. Hot Service Vents
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Calcium Silicate: 1-1/2 inches thick.
      b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

F. Refrigerant Piping
   1. Insulation shall be one of the following with vapor barrier:
      a. Flexible Elastomeric: 1 inch thick.
      b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

3.19 OUTDOOR PIPING INSULATION SCHEDULE

A. Chilled Water Supply and Return
   1. NPS 2 and Smaller: Insulation shall be the following with vapor barrier:
      a. Cellular Glass, Preformed Pipe, Type I: 3 inches thick.
   2. NPS 2-1/2 and Larger: Insulation shall be the following:
      a. Cellular Glass, Preformed Pipe, Type I: 3 inches thick.

B. Heating Hot-Water Supply and Return
   1. NPS 2 and Smaller: Insulation shall be the following with vapor barrier:
      a. Cellular Glass, Preformed Pipe, Type I: 3 inches thick.
   2. NPS 2-1/2 and Larger: Insulation shall be the following:
      a. Cellular Glass, Preformed Pipe, Type I: 3 inches thick.

C. Hot Service Drains
   1. Insulation shall be one of the following with vapor barrier:
      a. Cellular Glass: 2 inches thick.

D. Hot Service Vents
   1. Insulation shall be one of the following with vapor barrier:
      a. Cellular Glass: 2 inches thick.

E. Refrigerant Piping
   1. Insulation shall be one of the following with vapor barrier:
      a. Cellular Glass: 2 inches thick.

3.20 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Ducts and Plenums, Concealed: None.

C. Ducts and Plenums, Exposed in occupied spaces
   1. None.

D. Ducts and Plenums, Exposed in mechanical rooms
   1. Woven Glass-Fiber Fabric.

E. Piping, Concealed: None.

F. Piping, Exposed in occupied spaces
   1. PVC: 30 mils.

G. Piping, Exposed in mechanical rooms.
   1. Aluminum jacket.

3.21 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Ducts and Plenums, Concealed: None.

C. Internally lined ducts and plenums: None.

D. Piping, Concealed: None.

E. Piping, Exposed: Aluminum, Stucco Embossed Finish: 0.024-inch thick, with Z-Shaped locking seam.

END OF SECTION

SECTION 230800
COMMISSIONING OF HVAC

1.1 GENERAL

2.0 SUMMARY

3.0 SECTION INCLUDES COMMISSIONING PROCESS REQUIREMENTS FOR HVAC SYSTEMS, ASSEMBLIES, AND EQUIPMENT.

3.1 RELATED SECTIONS

A. Section 019113 – GENERAL COMMISSIONING REQUIREMENTS for general commissioning process requirements.

B. Section 015719 – CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT.

3.2 THIS PROJECT IS REQUIRED TO ACHIEVE CERTIFICATION UNDER LEED-NC V 2009. THE GREEN BUILDING PARAMETERS REQUIRED FOR THIS AFFECT ALL ASPECTS OF CONSTRUCTION. MATERIALS IN THIS SECTION IS SUBJECT TO THE REQUIREMENTS OF EAP1 WITH THE OPTION OF ATTEMPTING ENERGY AND ATMOSPHERE CREDIT 2, ENHANCED COMMISSIONING. PLEASE REVIEW THE LEED REQUIREMENTS SECTION 018113 OF THIS SPECIFICATIONS MANUAL.

2.1 DEFINITIONS

3.0 COMMISSIONING PLAN: A DOCUMENT THAT OUTLINES THE ORGANIZATION, SCHEDULE, ALLOCATION OF RESOURCES, AND DOCUMENTATION REQUIREMENTS OF THE COMMISSIONING PROCESS.

3.1 CXA: COMMISSIONING AUTHORITY.

3.2 HVAC: HEATING, VENTILATING, AIR CONDITIONING.

3.3 SYSTEMS, SUBSYSTEMS, EQUIPMENT, AND COMPONENTS: WHERE THESE TERMS ARE USED TOGETHER OR SEPARATELY, THEY SHALL MEAN "AS-BUILT" SYSTEMS, SUBSYSTEMS, EQUIPMENT, AND COMPONENTS.

2.2 ALLOWANCES

3.0 LABOR, INSTRUMENTATION, TOOLS, AND EQUIPMENT COSTS FOR TECHNICIANS FOR THE PERFORMANCE OF COMMISSIONING TESTING ARE COVERED BY THE "SCHEDULE OF ALLOWANCES" ARTICLE SECTION 012100 – ALLOWANCES.

2.3 CONTRACTOR'S RESPONSIBILITIES

3.0 PERFORM COMMISSIONING TESTS AT THE DIRECTION OF THE CXA.

3.1 ATTEND CONSTRUCTION PHASE CONTROLS COORDINATION MEETING.

3.2 ATTEND TESTING, ADJUSTING, AND BALANCING REVIEW AND COORDINATION MEETING.

3.3 PARTICIPATE IN HVAC SYSTEMS, ASSEMBLIES, EQUIPMENT, AND COMPONENT MAINTENANCE ORIENTATION AND INSPECTION AS DIRECTED BY THE CXA.

3.4 PROVIDE INFORMATION REQUESTED BY THE CXA FOR FINAL COMMISSIONING DOCUMENTATION.

3.5 PROVIDE MEASURING INSTRUMENTS AND LOGGING DEVICES TO RECORD TEST DATA,

AND PROVIDE DATA ACQUISITION EQUIPMENT TO RECORD DATA FOR THE COMPLETE RANGE OF TESTING FOR THE REQUIRED TEST PERIOD.

2.4 CXA'S RESPONSIBILITIES

3.0 PROVIDE PROJECT-SPECIFIC CONSTRUCTION CHECKLISTS AND COMMISSIONING PROCESS TEST PROCEDURES FOR ACTUAL HVAC SYSTEMS, ASSEMBLIES, EQUIPMENT, AND COMPONENTS TO BE FURNISHED AND INSTALLED AS PART OF THE CONSTRUCTION CONTRACT.

3.1 DIRECT COMMISSIONING TESTING.

3.2 VERIFY TESTING, ADJUSTING, AND BALANCING OF WORK ARE COMPLETE.

3.3 PROVIDE TEST DATA, INSPECTION REPORTS, AND CERTIFICATES IN SYSTEMS MANUAL.

2.5 COMMISSIONING DOCUMENTATION

3.0 PROVIDE THE FOLLOWING INFORMATION TO THE CXA FOR INCLUSION IN THE COMMISSIONING PLAN:

A. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

B. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

C. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.

D. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

E. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.

F. Test and inspection reports and certificates.

G. Corrective action documents.

H. Verification of testing, adjusting, and balancing reports.

2.6 SUBMITTALS

3.0 CERTIFICATES OF READINESS.

3.1 CERTIFICATES OF COMPLETION OF INSTALLATION, PRESTART, AND STARTUP ACTIVITIES.

3.2 ALL FORMS FOR LEED NC V2009 EAP1 AND EAC2 (IF APPLICABLE).

1.2 PRODUCTS

2.0 NOT USED

1.3 EXECUTION

2.0 TESTING PREPARATION

3.0 CERTIFY THAT HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT HAVE BEEN INSTALLED, CALIBRATED, AND STARTED AND ARE OPERATING ACCORDING TO THE CONTRACT DOCUMENTS.

3.1 CERTIFY THAT HVAC INSTRUMENTATION AND CONTROL SYSTEMS HAVE BEEN COMPLETED AND CALIBRATED, THAT THEY ARE OPERATING ACCORDING TO THE CONTRACT DOCUMENTS, AND THAT PRETEST SET POINTS HAVE BEEN RECORDED.

3.2 CERTIFY THAT TESTING, ADJUSTING, AND BALANCING PROCEDURES HAVE BEEN COMPLETED AND THAT TESTING, ADJUSTING, AND BALANCING REPORTS HAVE BEEN SUBMITTED, DISCREPANCIES CORRECTED, AND CORRECTIVE WORK APPROVED.

3.3 SET SYSTEMS, SUBSYSTEMS, AND EQUIPMENT INTO OPERATING MODE TO BE TESTED (E.G., NORMAL SHUTDOWN, NORMAL AUTO POSITION, NORMAL MANUAL POSITION, UNOCCUPIED CYCLE, EMERGENCY POWER, AND ALARM CONDITIONS).

3.4 INSPECT AND VERIFY THE POSITION OF EACH DEVICE AND INTERLOCK IDENTIFIED ON CHECKLISTS.

3.5 CHECK SAFETY CUTOUTS, ALARMS, AND INTERLOCKS WITH SMOKE CONTROL AND LIFE-SAFETY SYSTEMS DURING EACH MODE OF OPERATION.

3.6 TESTING INSTRUMENTATION: INSTALL MEASURING INSTRUMENTS AND LOGGING DEVICES TO RECORD TEST DATA AS DIRECTED BY THE CXA.

2.1 TESTING AND BALANCING VERIFICATION

3.0 PRIOR TO PERFORMANCE OF TESTING AND BALANCING WORK, PROVIDE COPIES OF REPORTS, SAMPLE FORMS, CHECKLISTS, AND CERTIFICATES TO THE CXA.

3.1 NOTIFY THE CXA AT LEAST 10 DAYS IN ADVANCE OF TESTING AND BALANCING WORK, AND PROVIDE ACCESS FOR THE CXA TO WITNESS TESTING AND BALANCING WORK.

3.2 PROVIDE TECHNICIANS, INSTRUMENTATION, AND TOOLS TO VERIFY TESTING AND BALANCING OF HVAC SYSTEMS AT THE DIRECTION OF THE CXA.

A. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

B. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

C. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

D. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

2.2 GENERAL TESTING REQUIREMENTS

3.0 PROVIDE TECHNICIANS, INSTRUMENTATION, AND TOOLS TO PERFORM COMMISSIONING TEST AT THE DIRECTION OF THE CXA.

3.1 SCOPE OF HVAC TESTING SHALL INCLUDE ENTIRE HVAC INSTALLATION, FROM CENTRAL EQUIPMENT FOR HEAT GENERATION AND REFRIGERATION THROUGH DISTRIBUTION SYSTEMS TO EACH CONDITIONED SPACE. TESTING SHALL INCLUDE MEASURING CAPACITIES AND EFFECTIVENESS OF OPERATIONAL AND CONTROL FUNCTIONS.

3.2 TEST ALL OPERATING MODES, INTERLOCKS, CONTROL RESPONSES, AND RESPONSES TO ABNORMAL OR EMERGENCY CONDITIONS, AND VERIFY PROPER RESPONSE OF BUILDING AUTOMATION SYSTEM CONTROLLERS AND SENSORS.

3.3 THE CXA ALONG WITH THE HVAC CONTRACTOR, TESTING AND BALANCING CONTRACTOR, AND HVAC INSTRUMENTATION AND CONTROL CONTRACTOR SHALL PREPARE DETAILED TESTING PLANS, PROCEDURES, AND CHECKLISTS FOR HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT.

3.4 TESTS WILL BE PERFORMED USING DESIGN CONDITIONS WHENEVER POSSIBLE.

3.5 SIMULATED CONDITIONS MAY NEED TO BE IMPOSED USING AN ARTIFICIAL LOAD WHEN IT IS NOT PRACTICAL TO TEST UNDER DESIGN CONDITIONS. BEFORE SIMULATING CONDITIONS, CALIBRATE TESTING INSTRUMENTS. PROVIDE EQUIPMENT TO SIMULATE LOADS. SET SIMULATED CONDITIONS AS DIRECTED BY THE CXA AND DOCUMENT SIMULATED CONDITIONS AND METHODS OF SIMULATION. AFTER TESTS, RETURN SETTINGS TO NORMAL OPERATING CONDITIONS.

3.6 THE CXA MAY DIRECT THAT SET POINTS BE ALTERED WHEN SIMULATING CONDITIONS IS NOT PRACTICAL.

3.7 THE CXA MAY DIRECT THAT SENSOR VALUES BE ALTERED WITH A SIGNAL GENERATOR WHEN DESIGN OR SIMULATING CONDITIONS AND ALTERING SET POINTS ARE NOT PRACTICAL.

3.8 IF TESTS CANNOT BE COMPLETED BECAUSE OF A DEFICIENCY OUTSIDE THE SCOPE OF THE HVAC SYSTEM, DOCUMENT THE DEFICIENCY AND REPORT IT TO THE OWNER. AFTER DEFICIENCIES ARE RESOLVED, RESCHEDULE TESTS.

3.9 IF THE TESTING PLAN INDICATES SPECIFIC SEASONAL TESTING, COMPLETE APPROPRIATE INITIAL PERFORMANCE TESTS AND DOCUMENTATION AND SCHEDULE SEASONAL TESTS.

2.3 HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

3.0 BOILER TESTING AND ACCEPTANCE PROCEDURES: TESTING REQUIREMENTS ARE SPECIFIED IN DIVISION 23 BOILER SECTIONS. PROVIDE SUBMITTALS, TEST DATA, INSPECTOR RECORD, AND BOILER CERTIFICATION TO THE CXA.

3.1 HVAC INSTRUMENTATION AND CONTROL SYSTEM TESTING: FIELD TESTING PLANS AND TESTING REQUIREMENTS ARE SPECIFIED IN SECTIONS 230923 – INSTRUMENTATION AND

CONTROL FOR HVAC AND 230960 – SEQUENCE OF OPERATIONS FOR HVAC CONTROLS. ASSIST THE CXA WITH PREPARATION OF TESTING PLANS.

3.2 PIPE SYSTEM CLEANING, FLUSHING, HYDROSTATIC TESTS, AND CHEMICAL TREATMENT REQUIREMENTS ARE SPECIFIED IN DIVISION 23 PIPING SECTIONS. HVAC CONTRACTOR SHALL PREPARE A PIPE SYSTEM CLEANING, FLUSHING, AND HYDROSTATIC TESTING PLAN. PROVIDE CLEANING, FLUSHING, TESTING, AND TREATING PLAN AND FINAL REPORTS TO THE CXA. PLAN SHALL INCLUDE THE FOLLOWING:

A. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

B. Description of equipment for flushing operations.

C. Minimum flushing water velocity.

D. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

3.3 ENERGY SUPPLY SYSTEM TESTING: PROVIDE TECHNICIANS, INSTRUMENTATION, TOOLS, AND EQUIPMENT TO TEST PERFORMANCE OF GAS SYSTEMS AND EQUIPMENT AT THE DIRECTION OF THE CXA. THE CXA SHALL DETERMINE THE SEQUENCE OF TESTING AND TESTING PROCEDURES FOR EACH EQUIPMENT ITEM AND PIPE SECTION TO BE TESTED.

3.4 REFRIGERATION SYSTEM TESTING: PROVIDE TECHNICIANS, INSTRUMENTATION, TOOLS, AND EQUIPMENT TO TEST PERFORMANCE OF REFRIGERANT COMPRESSORS AND CONDENSERS AND OTHER REFRIGERATION SYSTEMS. THE CXA SHALL DETERMINE THE SEQUENCE OF TESTING AND TESTING PROCEDURES FOR EACH EQUIPMENT ITEM AND PIPE SECTION TO BE TESTED.

3.5 HVAC DISTRIBUTION SYSTEM TESTING: PROVIDE TECHNICIANS, INSTRUMENTATION, TOOLS, AND EQUIPMENT TO TEST PERFORMANCE OF AIR, STEAM, AND HYDRONIC DISTRIBUTION SYSTEMS; SPECIAL EXHAUST; AND OTHER DISTRIBUTION SYSTEMS, INCLUDING HVAC TERMINAL EQUIPMENT AND UNITARY EQUIPMENT.

3.6 VIBRATION AND SOUND TESTS: PROVIDE TECHNICIANS, INSTRUMENTATION, TOOLS, AND EQUIPMENT TO TEST PERFORMANCE OF VIBRATION ISOLATION AND SEISMIC CONTROLS.

END OF SECTION

SECTION 230910
LABORATORY TRACKING SYSTEM AND AIRFLOW CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Related Sections include the following:
   1. Refer to Section 115313 – FUME HOODS AND OTHER AIR CONTAINMENT UNITS, for fume hood testing requirements.

B. Furnish and install Phoenix Medium Pressure Accel II Valves for all laboratory spaces as shown on the drawings. The existing campus Building Automation System (BAS) is Tridium Vykon Niagara 4. The Phoenix system shall be integrated to the building Energy Management Control System (EMCS). Provide interface device as necessary between laboratory airflow control system and the Tridium Vykon Energy Management Control System.

C. The Phoenix CELERIS system will be used for all laboratory spaces that have chemical fume hoods requiring high speed (<1 second speed of response) actuator capacities for proper VAV control. The Phoenix CELERIS system with low speed electric actuation will be used for all laboratory spaces with no fume hoods but have additional sequence requirements as noted by schedules and/or sequence of operation. All laboratory airflow control system shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain a constant average face velocity into the fume hood. The system shall have the capabilities to provide constant face velocity at either a standard in use or a standby level based on an operator being present in front of the fume hood. The laboratory control system shall vary the amount of the makeup supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain laboratory pressurization in relation to adjacent spaces. The laboratory airflow control system shall be capable of operating as a standalone system, or as a system integrated with the building automation system.

D. Installation of the air valves is by Division 23. Wiring and interface to the Energy Management Control System is to be furnished by Division 25. Start-up and System Commissioning to be furnished by Division 23 and 25.

E. See Commissioning Requirements Section 019113.

1.2 REFERENCE STANDARD

A. The latest published edition of a reference shall be applicable to this project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

C. All material, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

1.3 SUBMITTALS

A. Product Data: submit product data for all devices furnished for the laboratory airflow control system. Each air valve shall have the listed product name, model ordering number, design air flow rates and differential pressure requirements across the valve.

B. Record Drawings: submit complete point-to-point wiring diagrams for each applicable room configuration as shown on the drawings.

C. Submit as-built drawings listing all control device, and controller configuration for each controller.

D. Submit shop drawings and GUI submittal at the same time to allow for review of Lab control integration into the Tridium Niagra based controllers such as Vykon JACE Global Controllers.

1.4 TRAINING

A. Provide forty hours (5 days) training for Owner’s operation personnel in the use and maintenance of the laboratory airflow control system. Training shall be conducted during normal working houses and consist of both hands-on and classroom training at the job site.

B. All training shall be videotaped and submitted to Owner for their record.

1.5 WARRANTY

A. Warranty shall commence upon the date of acceptance and extend for a period of two years. Defects in materials and system performance shall be repaired by manufacturer at no cost to the Owner.

B. During the warranty period, if a service contract for the routine care, calibration, parts replacement, or upgrade of the system is required or recommended by the manufacturer, or such a contract is to be offered to the Owner during or after the warranty period, such contract and services shall also be included during the warranty period at no cost to the Owner.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standard, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 MANUFACTURER

A. Phoenix™ Controls Corporation.

B. Or equal.

2.3 LABORATORY AIR FLOW CONTROL SYSTEM

A. The laboratory air flow control system (LACS) shall be microprocessor based airflow control system that is used for research laboratories and other critical environments. The system shall have BACnet interfaced for bi-directional communication with the RSCCD Tridium Niagra Vykon JACE Global Control building automation system. The airflow control system shall provide data values, alarms, and set points used in each room environment control scheme to the EMCS and also provide remote diagnostics and comprehensive report and trends through the EMCS.

B. Each individual lab zone shall have a dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of twenty (20) network controlled airflow devices.

C. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel.

D. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position with no more than 5% overshoot or undershoot of the required airflow. Rate of sash movement shall be between 1.0 to 1.5 feet per second.

E. The hood exhaust airflow control device shall have a capability of automatically switching between in-use and standby levels based on operator presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.

F. The controller shall be integrated via BACnet with the following points as minimum. The EMCS contractor shall make the following points available on the GUI.

1. Fume Hood Exhaust Flow (CFM).
2. Supply / Makeup Airflow (CFM).
3. General Exhaust Airflow (CFM).

4. Total Lab Exhaust Flow (CFM).
5. Total Lab Supply Flow (CFM).
6. Room Offset (CFM).
7. Fume Hood Exhaust Low Flow Alarm.
8. Fume Hood Sash Position.
9. Computed Sash Flow (CFM).
10. Room differential pressure (using a through the wall differential pressure sensor).
11. Common Fume Hood Emergency Exhaust Alarm (Digital Contact).
12. Occupied, Unoccupied, and Emergency modes (command and status) of operation and associated command able and adjustable points, i.e. temperature set point, minimum and maximum airflow set point.

G. The control unit shall also accept direct input signals from the EMCS.

2.4 FUME HOOD CONTROLLER

A. Linear controller shall be installed on the sash mullion of each hood and shall provide user interface/alarm function and a linear control system, which translates the sash position into a proportional control signal to modulate the hood’s exhaust air valve. Hood airflow shall be varies to maintain a nominally constant face velocity at the hood opening. No air velocity sensors shall be employed. Hood airflow shall be varied to maintain a constant face velocity over no less than a 5 to 1 change in the sash open area (change in sash position).

B. Fume hood control system shall respond to and maintain the face velocity set point to ensure fume hood containment.

C. Provide a fume hood controller to receive a sash position signal from the sash sensor, process this signal and then output an exhaust airflow control signal to the hood exhaust valve.

D. The face velocity and minimum exhaust flow level of the fume hood shall be set at the fume hood monitor via trim pot adjustments. Accurate adjustments of the face velocity shall be provided at the minimum and maximum sash positions.

E. An emergency exhaust switch with an audible and dedicated visual alarm shall be provided on each fume hood monitor to override the sash sensor and command maximum exhaust airflow. Dedicated push to start, push to stop, push button switches shall force the hood exhaust volume control device to its full flow position and force the supply valve to its specified minimum or maximum position.

F. Fume hood controller shall have a visual and an audible annunciator to alarm the occurrence of a low face velocity. Muting of the annunciator will not cancel the visual alarm until the low flow condition is no longer present. The fume hood alarm shall be initiated by:

1. A differential pressure switch located across a hood exhaust valve that senses a reduction in airflow of approximately 20 percent of set point.
2. When the airflow value sent to the hood exhaust valve by the control unit is different than the actual airflow feedback value.
3. The sash being raised above a specified height and/or specified area for fume hoods not sized for 100 percent opening.
4. The alarm wire being disconnected.

G. The fume hood controller shall include an LCD readout to indicate face velocity of hood, green LED indication for normal operation, yellow LED an audible alarm for an unsafe flow condition, yellow LED and audible alarm for night energy waste alert and red LED and audible alarm to indicate emergency exhaust operation.

H. A pushbutton switch shall be provided to mute the audible alarms. The mute mode is automatically reset when the alarm condition ceases.

I. Each of the flows and system “offset” shall be adjustable.

J. A set of input contacts shall be provided inside the hood controller to remotely command the Emergency Exhaust mode from an external SPST contact.

K. Momentary or extended losses of power shall not change or affect any of the control system's set points, calibration settings, or emergency exhaust mode status. After power returns the system shall continue operation exactly as before without need of operator intervention. Under no circumstances shall loss of power command the exhaust system to full flow upon return of power.

L. Control power for the hood controller shall be provided from the supply air control panel.

2.5 FUME HOOD SASH POSITION SENSOR

A. A sash sensor shall be provided to measure hood sash position and output a sash position signal to the hood controller. The sash sensor shall consist of a precision ten turn potentiometer mechanically coupled to a constant tension spring reel. A stainless steel, vinyl-coated cable shall be attached to the spring reel. Expected lifetime based on manufacturer's component data and tests shall be over 200,000 full height sash movements.

B. The hood sash position sensor shall be designed to meet the UL 913, Class 1, Division 1, Groups C and D, and methane standard for intrinsically safe equipment used in hazardous locations.

2.6 AIRFLOW CONTROL DEVICES

A. The airflow control device shall be a Phoenix Accel II Venturi valve with an option for 100% shut off capabilities. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001-2000. The valve body is constructed of 16 gauge spun aluminum with continuous welded seam, composite Teflon shaft bearings, and a spring grade stainless steel spring in the slider assembly. Supply valves to be insulated with 3/8" flexible closed cell polyethelene insulation material. Airflow devices have an operating range of 32-122°F ambient at 10-90%RH.

B. The airflow control valve shall be pressure independent over its specified differential static pressure operating ranges. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.

C. The airflow control device shall maintain accuracy within +/-5% of signal over an airflow turndown range as shown in the table below and stated by the Venturi's original manufacturer's sizing chart in the "Ideal Selection Range" without exceeding 2000 FPM velocity through any airflow device and have no deviation or loss of accuracy through the entire range of the flow device.

Pressure Drop Range	Airflow	Turndown	Valve Type
0.6- 3.0 in w.c. Medium Pressure	Devices up to 1,000 CFM	20 to 1	Standard
	Devices up to 1,500 CFM	16 to 1	Standard
	Devices up to 2,500 CFM	12 to 1	Standard
	Devices up to 850 CFM	17 to 1	Shutoff
	Devices up to 1,300 CFM	14 to 1	Shutoff

D. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

E. The airflow control device shall be constructed of one of the following three types or classes:

1. Class A – Body and cone of uncoated aluminum, shaft uncoated stainless steel.
2. Class B – Body and cone with phenolic coating, PFA coated stainless steel shaft. (For standard fume hood, snorkel and biological safety cabinet application).
3. Class C – Body, cone and hardware with phenolic coating, PFA coated stainless steel shaft (for highly corrosive fume hood application)

F. For two position or VAV operation, an electric actuator shall be factory mounted to the valve. Loss of control power shall cause the actuator to fail in last position. When failed in last position, pressure independent airflow control is to be maintained by the airflow control device during power failure. Electrical actuators that fail in last position exclusively are not acceptable. Tracking pair low speed electric actuators fail in last position, but will continue to control airflow and be pressure independent with not power.

G. The controller for the airflow control devices shall be microprocessor based and operate using a peer-to-peer control architecture. The room level airflow control devices shall function as a standalone network or can be fully integrated with EMCS.

H. The room level control network shall utilize a BACnet peer to peer communications protocol.

I. There shall be no reliance on external or building level control devices to perform room level control functions. Each laboratory control system shall have the capability of performing: Fume hood control, Pressurization control, Temperature control and implement Occupancy and Emergency mode control schemes.

J. The laboratory airflow control system shall integrate digitally with the EMCS through BACnet Ethernet connect.

K. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of forty-eight different airflows across the full operating range of the device. All flow data for any given device shall be stored at the factory and be available on presentation of the unique serial number within 24 hours. Flow data for all valves shall be stored at a location away from the factory for disaster recovery purposes.

L. All airflow control devices shall be individually marked with device specific, factory calibration data. At a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as built documentation

M. Valves will be selected and sized to not exceed the flow and pressure ranges in the following table:

Description	Size	Operating Range in CFM		Valve Type
		Single	Dual	
M- Medium Pressure 0.6” – 3.0	8”	35 - 650		Standard
	10”	50 - 900		Standard
	12”	90 - 1350	180 - 2850	Standard
	14”	200 - 2300	400 - 4750	Standard
M- Medium Pressure 0.6” – 3.0	8”	35 - 500		Shut - Off
	10”	50 - 800		Shut - Off
	12”	90 - 1200	180 - 2500	Shut - Off
	14”	200 - 1500	400 - 3000	Shut - Off

N. The shutoff airflow control device shall have a shutoff and casing leakage of no more than:

Static Pressure Across Valve in Shutoff	Airflow	Shutoff Leakage	Casing Leakage
5.0 in w.c.	Shutoff devices up to 850 CFM	6 CFM	0.12 CFM/ ft²
	Shutoff devices up to 1,300 CFM	6 CFM	0.12 CFM/ ft²
	Low leakage shutoff devices up to 850 CFM	0.005 CFM	0.010 CFM/ ft²
	Low leakage shutoff devices up to 1,300 CFM	0.010 CFM	0.010 CFM/ ft²

O. 100% shutoff sequence can be initiated through a universal input or remotely via the local area network from the EMCS or a local display unit. 100% shutoff confirmation is available through a local digital output or an integrated point. The 100% shutoff confirmation is required by positive position verification.

2.7 CONTROL FUNCTION

A. The airflow control devices shall utilize a peer-to-peer, distributed control architecture to perform room-level control functions. Master/Slave control schemes shall not be acceptable. Control functions shall at a minimum include, pressurization, temperature, humidity control and respond to occupancy and emergency control command.

B. Pressurization Control

1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
2. The pressurization control algorithm shall sum the flow values of all Supply and Exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.
3. With the Celeris system, the pressurization control algorithm shall support the ability to regulate the distribution of total supply airflow across multiple supply airflow control devices or total general exhaust airflow across multiple exhaust airflow control devices in order to optimize air distribution in the space.
4. Where shown on the drawings, differential room pressure is to be monitored by a Critical Room Control. (CRC-RM)
   a. The room pressure controller (Controllers) shall be capable of measuring the differential pressure between two individual spaces at all locations shown on the prints. Each room shall have its own controller capable of stand-alone operation. Each monitor is capable of both visual and audible alarms. Each monitor will use direct pressure measurement utilizing industrial quality differential pressure transducer technology.
   b. Implied pressure measurement systems utilizing thermal (hot wire or thermal mass) air velocity measurement are not acceptable.
   c. Each monitor shall have an easy to navigate microprocessor based controller with full color TFT touch screen interface. Touch screen shall be capable of displaying room conditions in full color i.e. Red screen for alarm. All settings and programming shall be made via simple touch screen.
   d. Display shall be fully programmable with custom graphics and fonts. Monitor will store all settings in nonvolatile memory. Monitor to be capable to incorporate custom JPEG's or BMP's for display. Monitor will continually display room differential pressure. Monitor settings shall be accessed via programmable and password protected touch screen. Monitor shall be capable of custom color, graphics and messages per the owner. Monitor shall be recess mounted. Supply voltage shall be 24 volt ac/dc.
   e. The sensor shall continuously monitor and or control bi-directional room pressurization using direct pressure sensing referenced to the adjacent space. Wall / ceiling mounted assembly fittings and stainless steel cover plate shall be provided with the controller as a complete unit.
   f. Performance:
      1) Each monitor will use direct pressure measurement utilizing industrial quality differential pressure transducer technology.
      2) Accuracy Class (F.S.): shall be 0.4 - 0.8%. Accuracy includes the effects of linearity, hysteresis and repeatability. Stability maximum change F.S./year .5%. Monitor shall be bi-directional. Operating temperature shall be -40 to 180 degrees F. The room pressure controller shall be factory calibrated. The room pressure transducer shall factory calibrated with NIST traceable standards.
      3) Each Monitor shall incorporate a high speed microprocessor based controller, designed for critical environment control applications.
      4) Each monitor shall have four (4) universal analog inputs for 4-20mA, 0-5V and 0-10V jumper selectable.
      5) Each monitor shall have two (2) 0-10V and two (2) 4-20mA analog outputs, four (4) digital inputs, and four (4) digital Contact (relay) outputs.
      6) Each controller shall have a two (2) wire RS485 serial network interface.
      7) The room pressure monitor shall be mounted in the corridor adjacent to the lab entrance. Monitor shall be in clear view for staff in corridor

C. Temperature Control

1. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five (5) temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writable from the EMCS, with the option of a local offset adjustment.
2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
3. The laboratory control system shall also provide the built-in capability for being configured for Hot Deck/Cold Deck temperature control.
4. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a stand-alone temperature control loop, or staged to supplement the corresponding primary temperature control loop.

D. Occupancy Control

1. The laboratory control system shall have the ability to change the minimum ventilation (supply airflow) and temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the EMCS, as a scheduled event, or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied, for a predetermined interval. The override interval shall be configurable for 1 to 1,440 minutes. The local occupancy sensor/switch, or bypass button shall be given priority over an EMCS command.

E. Emergency Mode Control

1. The laboratory control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists and airflow control devices are to be driven to a specific flow set point. The system shall support up to four (4) emergency control modes. The emergency control modes may be initiated either by a local contact input, or EMCS command.
2. Once an Emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

F. Airflow Shutoff Control

1. The airflow control devices shown on the drawings and schedules as type SOV shall be capable of shut off function. Each device shall be capable of accepting a digital input to switch each individual air valve from the set point flow to shutoff position. This valve shall utilize an electric actuator with fail to last position operation. Feedback shall be available to indicate flow and shutoff. Confirmation of shut off shall be available through a digital output. These valves shall also be capable of network operation and being commanded to shutoff position from the EMCS.

2.8 TERMINAL UNIT CONNECTIONS

A. Single valve terminal unit duct connections shall consist of round inlet connections suitable for flanged and bolted connection to rigid round duct as detailed on the Drawings. If circular bolt flanges are not noted on the drawings, then the Controls Valve Draw band Clamp kit shall be utilized on both the inlet and outlet connections to the ductwork. Standard slip-in duct connections with sheet metal screws and sealer is not acceptable. Where multiple valves are employed, a common inlet plate suitable for slip connection to a single rectangular duct inlet duct shall be factory installed on the terminal unit using a press fit and silicone seal connection.

2.9 EMCS INTEGRATION

A. The room controllers shall be capable of direct communications with the existing campus Tridium Vykon system via BACnet open protocol.

B. The EMCS shall be interfaced to allow remote monitoring of specified controller outputs and inputs and shall be capable of resetting room temperature set point.

C. The EMCS interface must be installed and fully operational before the control system will be accepted.

D. The airflow control device shall have provisions to connect to a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.

2.10 CONDUIT AND WIRING SYSTEM

A. Cabling for these systems shall be either fiber optic, 24 AWG shielded twisted copper pair, or a mix of both. The Owner will consider exceptions to this requirement only if the laboratory tracking systems and constant volume valve manufacturer provides technical documentation, demonstrating that:

1. This system will not function unless a different type of cable is used.
2. The National Electrical Code requires cables to be shielded

PART 3 EXECUTION

3.1 PREPARATION

A. Provide a Project Manager, who shall, as a part of the Project Manager’s duties, be responsible for the following activities:

1. Coordination between the Contractor and all other trades and Owner’s Representative.
2. Scheduling of manpower, material delivery, equipment installation, and checkout.
3. Maintenance of construction records such as Project scheduling, manpower planning, and AutoCAD Drawings for Project coordination and As-Built Drawings.

3.2 CALIBRATION

A. Each airflow control valve shall be factory calibrated to the Project specific airflows as detailed on the Contract Documents. Valve shall be electronically calibrated / characterized at the factory by certified NIST traceable air stations. The valve’s characterization shall be determined at eight (8) unique airflows including a test of the valve’s pressure independence at three (3) different static pressures. A total of nineteen (19) airflow checks shall be performed and recorded for each air valve. All information shall be stored on computer diskette in ASCII format for future retrieval or for hard copy printout.

B. Field adjustment shall not be required other than minor changes as required by the TAB Firm. Accuracies and performance shall be guaranteed as specified irrespective of field conditions.

C. Air shall be maintained plus or minus 5 percent of the design air quantity setting (subject to valve maximum and minimum CFM limits) over an inlet static pressure rate of 0.6 to 3.0 inches static pressure.

3.3 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer’s published recommendations.

C. Coordinate hood installation provisions with the project hood supplier.

D. Coordinate the placement and installation of the sash position sensor with project hood supplier or manufacturer.

3.4 FIELD QUALITY CONTROL

A. During the Test and Balance and commissioning, the laboratory controls contractor shall be required to perform testing, measurement and commissioning activities with the test and balance agency and the commissioning authority.

END OF SECTION

SECTION 230913
BUILDING AUTOMATION SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. This section includes primary HVAC equipment controls for HVAC Energy Management Control System (EMCS), including control components for terminal heating and cooling units.

B. Related Sections include the following:
   1. Section 230519 "METERS AND GAGES FOR HVAC PIPING" for measuring equipment that relates to this Section.
   2. Section 230593 “TESTING, ADJUSTING AND BALANCING FOR HVAC”.
   3. Section 230923 “INSTRUMENTATION AND CONTROL DEVICES FOR HVAC” for control devices and equipment that relate to this Section.
   4. Section 230960 "SEQUENCE OF OPERATIONS FOR HVAC CONTROLS" for requirements that relate to this Section.
   5. See Commissioning Requirements section 019113.

1.2 SCOPE OF WORK

A. The Contractor shall furnish and install a fully integrated Energy Management Control System, incorporating direct digital control (DDC) for environmental controls, energy management, equipment monitoring and control, and subsystems as herein specified. The installation of the control system shall be performed under the direct supervision of the Contractor with approved shop drawings, flow diagrams, bill of materials, point-to-point wiring diagrams and sequences of operation.

B. All materials and equipment shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years in the U.S. commercial or industrial controls industry.

C. Contractor shall be responsible for all EMCS and instrumentation wiring for a complete and operable system. All wiring shall be installed in accordance with all applicable code requirements.

D. Contractor shall comply with all Owner standards for graphic development, graphic navigation, point naming convention, controller programming, and analog point change of state limits. The Contractor will be provided the basic background graphic system displays on an as-need basis to meet Owner operation requirements.

E. Contractor shall install all wells, valves, pressure taps, control dampers, air flow stations, etc. Contractor is also responsible for EMCS control panel and instrumentation factory mounting charges on primary HVAC equipment and terminal units before shipping to job site.

F. Contractor provides:
   1. 120 V power junction boxes for all EMCS and/or temperature control panels.
   2. Wiring of all power feeds through all disconnects and starters to electrical motors.
   3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices.
   4. All fire alarm interface wiring to HVAC equipment, fire/smoke dampers or other devices required for fire safety shutdown.

G. The contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control for energy management, equipment monitoring and control, and sub-systems with open communication capabilities as specified.

H. Furnish all labor, materials and equipment for the fully integrated building automation system, complete temperature control system as specified herein. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.

I. The control system shall be web based and be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

J. Provide DDC control products in sizes and of capacities as required, conforming to manufacturer's standard materials and components as published in their product information, designed and constructed as recommended by the manufacturer and as required for application indicated.

K. System shall be capable of operating with 120VAC power supply, fully protected with a shutdown-restart circuit, and associated hardware and software.

1.3 SYSTEM DESCRIPTION

A. General: The control system shall consist of a high speed peer to peer network of BACnet IP and MSTP field level controllers, building level Java Application Control Engine (JACE) Global Controllers, and seamless integration of building level controllers with an existing RSCCD Tridium Building Management System Server utilizing the Niagara Platform.

B. The existing Tridium Niagra AX Supervisor, S-AX-100, is installed on a campus virtual server currently located at Santiago Canyon College and is supported by District ITS. The server includes Niagra Historical Databases and Workplaces AX, OBIX client/server drivers for connecting to Niagra-based controllers such as the Vykon JACE Global Controller. The software is licensed to the RSCCD with no license restrictions. Each building shall have its own JACE Global Controller of differing modules at the building level. The JACE is the building level controller which connects to systems as defined in the contract documents.

C. System shall use the BACnet protocol for communication to the operator workstations and web server and for communication between control modules. I/O points, schedules, set-points, trends and alarms specified in Sequence of Operation shall be BACnet objects.

1.4 DEFINITIONS

TERM	DEFINITION
BACnet Interoperability Building Blocks (BIBB)	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
Controller	Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.
Direct Digital Control (DDC)	Microprocessor-based control including Analog/Digital conversion and program logic.

Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Passing (MSTP)	Data link protocol as defined by the BACnet standard.
Point-to-Point	Serial communication as defined in the BACnet standard.
Primary Controlling LAN	High speed, peer-to-peer controller LAN connecting LAN GATE ROUTERs and optionally Zone Controllers and System Controllers. Refer to System Architecture below.
Protocol Implementation Conformance Statement	A written document that identifies the particular options specified by BACnet that are implemented in a device.
Router	A device that connects two or more networks at the network layer.

1.5 QUALITY ASSURANCE

A. Contractor shall have established a 10-year working relationship with control manufacturer and evidence of successful prior performance and Tridium installation and integration. Contractor shall have an in-place support facility within 50 miles of the Owner with technical staff, spare parts inventory and necessary test and diagnostic equipment.

B. Upon request, Contractor shall present record of completed Tridium certification training and/or field controller training for control system, including course outlines for review by the District. Contractor shall provide a record of Tridium installations in the past 5 years with contact names, company names and project size information.

C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be the manufacturer's latest standard design that complies with these specification requirements.

D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, governing Radio Frequency Electromagnetic Interference and be so labeled.

E. Have manufacturer of the building automation system furnish documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing).

1.6 SUBMITTALS

A. Submit complete set of documentation for designed system approval:
   1. Direct Digital Control (DDC) System Hardware.
      a. A complete bill of materials to be used indicating quantity, manufacturer, model number and relevant technical data of equipment to be used.
      b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below.
         1) Thermostats.
         2) Direct Digital Controllers (Control Panels)
         3) Transducers and transmitters.
         4) Sensors.
         5) Actuators.
         6) Valves.
         7) Relays and switches.
         8) Current switches.

9) Control panels.
10) Power Supplies.
11) Batteries.
12) Operator interface equipment.
13) Wiring.

c. Wiring Diagrams and layouts for each control panel. Show termination numbers.
d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software.
   a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical cutsheets.
   b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
      1) Web Server (the web server will reside on RSCCD's virtual server for redundancy and maintenance). Contractor shall coordinate with the District's Representative prior to interfacing to the Niagra Supervisor located on the District's virtual server.
      2) JACE Global Controller (List Model and Points Counts and Spare Point Counts).
      3) Building Gateway Router.
      4) Monitors.
      5) Keyboards.
      6) UPS Battery backups.
      7) Interface equipment between Web Server and Building Gateway Router and System Controllers.
      8) Operating System software.
      9) Operator interface software.
      10) Color graphic software.
      11) Third-party software.
   c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
   d. Network riser diagrams of wiring between central control unit and control panels.
3. Controlled Systems.
   a. Riser diagrams showing control network layout, communication protocol, and wire types
   b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
   c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
   d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
   e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, Electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
   f. A complete description of the operation of the control system, including revised sequences of operation, if different from the Specified Sequence of Operation. List all deviations from the Specified Sequence of Operation. The description shall include and reference a schematic diagram of the controlled system.
   g. A point list for each control system confirming the I/O points and software points specified in the plans. Indicate alarmed and trended points. Indicate spare point list.
4. Project Record Documents: Upon completion of installation, submit two copies of record (as-built redline) of the Approved Construction Drawing Set. Documents shall be submitted for approval, as work is completed, prior to final completion and shall comprise of

a. Contractor shall embed the final as-built into the system graphics for download via PDF format for quick reference utilizing Tridium graphics. This as-built shall be placed into each specific page for each building.
b. Final and Redlined Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2016 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
c. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Commissioning Specification.
d. Final Operations and Maintenance (O&M) Manual.
e. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
f. Final and redlined documentation of programs created using custom programming language including set-points, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, set- points, tuning parameters, and objects can be viewed using furnished programming tools.
g. Final and Revised Graphic files, programs, and database on magnetic or optical media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors
j. Warranty documents for equipment and systems
k. Recommended preventive maintenance procedures.
l. Point to point verification and calibration report per the Commissioning Specifications.

5. Training Materials: Provide course outline and materials for each class at least two weeks before first class. District will modify course outlines and materials if necessary to meet Owner’s needs. Training shall be furnished via Start-up Technician. Engineer will review and approve course outlines and materials at least one week before first session

1.7 OWNERSHIP OF PROPRIETARY MATERIAL AND SOFTWARE LICENSE AGREEMENT

A. It is the Owners express goal to implement an open system that allows products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.

B. In addition, the Owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use within JACE Controllers, Web Supervisor(s), (or their appropriate trade names) and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required Ids and passwords for access to any component or software program shall be provided to the Owner”.

C. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics.
2. Record Drawings.
3. Database.
4. Application programming code.
5. Operating Environment Software.
6. Documentation.

1.8 SYSTEM PERFORMANCE

A. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer’s recommended hardware and software for server and browser for web-based systems.

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.

3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple-Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in **TABLE 1.**
10. Control Stability and Accuracy. Control loops shall maintain measured variable at set-point within tolerances listed in **TABLE 2**

TABLE-1 Reporting Accuracy

MEASURED VARIABLE	REPORTED ACCURACY
Space Temperature	±0.20ºC (±0.36ºF)
Ducted Air	±0.20ºC (±0.36ºF)
Outside Air	±0.20ºC (±0.36ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.20ºC (±0.36ºF)
Delta-T	±0.15º (±0.25ºF)
Relative Humidity	±2% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±2% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. W.G.)
Air Pressure (space)	±3 Pa (±0.01 in. W.G.)
Water Pressure	±2% of full scale (see Note 2)
Electrical	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 PPM

Note 1: Accuracy applies to 10%–100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

TABLE-2 Control Stability and Accuracy

CONTROLLED VARIABLE	CONTROLLED ACCURACY	RANGE OF MEDIUM
Air Pressure	±50 Pa (±0.2 in. W.G.) ±3 Pa (±0.01 in. W.G.)	0–1.5 kPa (0–6 in. W.G.) -25 to 25 Pa (-0.1 to 0.1 in. W.G.)

Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. W.G.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. W.G.) differential

1.9 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire EMCS for a period of two years after the Owner's formal acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

B. The adjustment, required testing, and repair of the system shall include all computer equipment, transmission equipment, system operating sequences and all instrumentation sensors and actuator devices.

C. If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification

D. Emergency Service shall be provided the next business day after receiving a request for service that identifies the system is not functioning properly. Furnish the Owner with telephone numbers where service representatives can be reached during normal business hours. Service personnel shall be at the campus the next business day after receiving a request for service.

E. Coordinate with the Owner's Facilities Management and CxA for a system inspection and testing 6 months after beneficial use and 2 months prior to end of warranty to correct all deficiencies discovered by the Owner and CxA during normal occupied building operation.

PART 2 PRODUCTS

2.1 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet inter network. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet, or as approved by the District.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

2.2 ENERGY MANAGEMENT CONTROL SYSTEM AND COMPONENTS DESCRIPTION

A. The Energy Management Control System (EMCS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system, graphical user interface software, network devices, and other devices as specified herein.

1. System shall employ all standard features and functions as described herein to monitor and control building equipment. At a minimum, the following data shall be accessible:
   a. Space temperature
   b. Space temperature set point
   c. Occupancy status

d. Operating mode
e. Window status
f. Valve positions
g. Air volume flow
h. Percent terminal load
i. Time schedules
j. Zero energy bands
k. Room name
l. Terminal type e.g. fan coil

2. In the event of a power failure or disconnection from the network, the controllers shall continue to be fully operational with full time program capability.

B. Web Browser Clients shall support at a minimum, the following functions:

1. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
3. Storage of the graphical screens shall be in the Tridium Supervisor without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
4. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
5. Contractor shall coordinate with District ITS and District Representative to configure Owner issued computer to connect to the Tridium Niagara Supervisor.

2.3 SYSTEM PROGRAMMING

A. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.

B. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real- time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

C. Programming Methods:

1. Programming of equipment sequences shall be performed graphically and shall be stored in VSD file format (Microsoft Visio).
2. Program files shall be stored at each JACE Global Controller, as well as collectively at the virtual server location in a backup database which updates automatically. In the event of power or communications loss with the main server, JACE Global Controllers and Field Controller shall continue to operate based on the last known system status and the operations shall be based on the programming residing on the Global Controllers. Upon power/communication restore to the Virtual Server,
3. Global Controllers shall send all updates during the server loss including historical data and alarm data to the Supervisor and shall resume normal operations.

D. Scheduling: Provide the capability to schedule each object or group of objects in the controller system. Controllers shall have a minimum of 20 schedules. Schedules shall be coordinated with the Contract Documents, the District Representative, and the Campus prior to acceptance of the system.

E. Staggered start: This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment or groups of equipment is started, along with the time delay between starts, shall be user-selectable.

F. Anti-short cycling: Digital output objects shall be protected from short cycling. This feature shall allow minimum on time and off time to be selected.

G. On and off control with differential: Provide an algorithm that allows a digital output to be cycled based on a controlled variable and set point. Algorithm shall be direct acting or reverse acting and incorporate an adjustable differential.

H. Duty cycle: Provide software to switch HVAC systems on and off at variable intervals to save energy while maintaining room conditions. Program shall have adjustable internal parameters for room comfort range, maximum off times, minimum off times, and motor cycle times.

I. Fault Detection & Diagnostics (FDD)
   1. Email notification: Provide automatic notification of detected issues via email. Coordinate with District Representative and Campus the equipment types that will require email notification. As a minimum provide:
      a. Immediate notification of detected issues
      b. Weekly digest or summary of detected issues
      c. The ability to delineate which issue notifications are sent to which recipients down to the level of specifying individual issues are sent to individual recipients
   2. Reporting: System shall have the ability of generating reports.
   3. Energy and Water Specific Reporting and Information Presentation Tools
      a. Energy and Water Consumption Baseline - The analytic software application shall provide the ability to quantify and define energy consumption and demand baselines. It shall also allow for definition of other normalization metrics based on customer data without dependence on the software manufacturer for custom development.
      b. Benchmarking - The analytic software application must support multi-site benchmarking, allowing the user to compare energy consumption and demand profiles and baselines across all buildings within the users enterprise.
      c. Tracking of Key Performance Indicators - The analytic software shall allow for the definition and tracking of user defined key performance indicators/operational metrics. Examples include: energy demand and consumption normalized for area and weather, peak demand and consumption shown with minimum and maximum ranges across any user selectable period of time.
      d. Correlation of Energy Use with Equipment Operation - The analytic software shall provide as a standard function the ability to automatically present views that show the correlation between energy demand and consumption and the operation of the loads associated with that usage. This capability will extend to all meters including sub-meters and virtual meters. Correlation views shall be able to include weather data as a selectable item.
   4. Economizer: Provide software that determines the most economical system operation for full and partial air conditioning systems. For a full air conditioning plant, it calculates the control signal for energy recovery on the basis of actual outdoor air enthalpy, return air enthalpy, and demand. In partial air conditioning systems, this control icon shall be used for heat recovery with temperature comparison. Economizer program shall make decisions based on the following information: Is the system a full or partial air conditioning system. A full system has temperature and humidity control. A partial system has temperature control only.
   5. Optimum start and stop: Provide a software program that calculates optimized values for starting and stopping the heating plant. Optimized start-stop function shall consider the residual heat in a building to avoid unnecessary heating operation. Required room conditions are met at all times. Optimum start and stop program calculates required flow temperature with an integrated heating curve. Two techniques shall be available: optimization without room sensor or optimization with room sensor. Optimization without room sensor uses outdoor air temperature to determine optimum start (the preheat point). Optimization with room sensor uses room control and needs a time constant (time program) and dead time to calculate the preheat point.

6. Run-time totalization: Provide software to totalize run times for all mechanical equipment. A high run-time alarm shall be assigned, if required, by the operator.
   a. Data references like text descriptors, historical data, alarm buffer, engineering units, engineering characteristics etc. must be resident inside the building controller.

2.4 SERVER FUNCTIONS AND HARDWARE

A. Graphics:
   1. All graphics shall be stored at the existing RSCCD Tridium Niagara Supervisor.
   2. System Graphics. The operator interface software 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 set-point.
      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 set-points 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.
   3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
   4. Graphics Library. To ensure system uniformity, all graphics shall utilize the existing RSCCD Tridium Niagara graphics library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also includes standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Graphics not currently included in the RSCCD Tridium Niagara graphics library shall be coordinated with District Representative and created by Contractor.
   5. The Contractor shall provide the campus sample graphics for review and comment prior to finalizing. The District has graphic templates that will be shared and coordinated with the Contractor for implementation.

2.5 NETWORK AREA CONTROLLER (NAC)

A. Manufacturer:
   1. Vykon, JACE Global Controllers (Basis of Design), or District approved equal.
      a. Equal product shall offer open programming capabilities, no license restrictions, and no lockouts proprietary to the brand.
      b. Every application specific, unitary, or integrated controller shall be connected to the NAC via BACnet MSTP or BACnet IP.

B. The NAC shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
   1. Calendar functions
   2. Scheduling
   3. Trending
   4. Alarm monitoring and routing
   5. Time synchronization
   6. Network Management functions for all controllers

C. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

D. Event Alarm & Notification Actions:
   1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network connection, or wide-area network.
   3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      a. To alarm
      b. Return to normal
      c. To fault
   4. Provide for the creation of a minimum of multiple alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
   5. Provide timed (schedule) routing of alarms by class, object, group, or node.
   6. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
   7. Control equipment and network failures shall be treated as alarms and annunciated.
   8. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text
      b. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on: Day of week; time of day; and recipient
      c. Graphic with flashing alarm object(s)
   9. The information recorded by the NAC messaging component shall be coordinated with the District Representative and Campus.
   10. Alarm actions may be initiated by user defined programmable objects created for that purpose.
   11. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
   12. A log of all alarms shall be maintained by the NAC and a the Niagra Supervisor server (if configured in the system) and shall be available for review by the user.
   13. Provide a “query” feature to allow review of specific alarms by user defined parameters.
   14. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

E. Data Collection & Storage: The NAC shall have the ability to collect data for any property of any object and store this data for future use.

F. Audit Log: Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server.

G. For each log entry, coordinate with the District Representative and the Campus regarding the desired data to be collected.

H. Database Backup & Storage:
   1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user- defined time interval.
   2. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.

I. Graphical User Interface Software
   1. Operating System:
      a. The GUI shall run on the most current version Microsoft Windows.
   2. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:

a. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable.

3. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
   a. Create, delete or modify control strategies.
   b. Adjust set points
   c. Add schedules
   d. Add/delete objects to the system.
   e. Tune control loops through the adjustment of control loop parameters.
   f. Enable or disable control strategies.
   g. Generate hard copy records or control strategies on a printer.
   h. Select points to be alarmed and define the alarm state.
   i. Select points to be trended over a period of time and initiate the recording of values automatically.

2.6 MECHANICAL EQUIPMENT AND AIR DISTRIBUTION

A. Acceptable Manufacturers:
   1. Alerton
   2. Automated Logic
   3. Delta Controls
   4. Or District Approved equal capable of integrating into the Tridium Global Controllers and Niagra Supervisor.

B. The Contractor shall use only interface software, controller software, and custom application programming languages, compatible with Tridium Niagara Supervisor.

C. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line.

D. Mechanical equipment controllers are required for the following components:
   1. Air handler units
   2. Rooftop units
   3. Boilers
   4. Chillers
   5. Heat pumps
   6. Condensers
   7. Exhaust fans
   8. Fan coil units
   9. Terminal units such as VAV boxes

2.7 AUXILIARY FIELD CONTROLLERS

A. Additional auxiliary field controllers and components required for a complete building automation system:

   1. Valve actuators
   2. Electric dampers
   3. Control valves
   4. Water valves
   5. Binary temperature devices
   6. Low voltage thermostats
   7. Line voltage thermostats
   8. Temperature sensors
   9. Humidity sensors
   10. Flow switches
   11. Control and time delay relays
   12. Current transmitters
   13. Current transformers

14. Current switches
15. Voltage transmitters
16. Voltage transformers
17. Power monitoring
18. Water monitoring
19. Hydronic flow meters
20. Thermal energy meters
21. Pressure transducers
22. Differential pressure switches
23. Pressure electric switches
24. Occupancy sensors

2.8 NETWORK COMMUNICATION

A. The design of the DDC shall be network operator workstations and stand-alone DDC controllers. The network architecture shall consist of three levels, a complex wide Ethernet network based on TCP/IP protocol, a high performance peer-to-peer building level network and DDC controller floor level local using serial communications. Inherent in the system's design shall be the ability to expand or modify the highest network either via a local area network (LAN), wide area network (WAN), or a combination of the two schemes.

B. The design of EMCS shall allow the co-existence of new DDC controllers with existing DDC controllers in the same network without the use of gateways or protocol converters.

C. System to be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, trend data collection, lighting control, building access control, security, fire alarm etc.

D. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, application specific controllers, and operator devices.

E. The failure of any single component or network connections shall not interrupt the execution of control strategies at other operational devices.

F. Management Level Network

1. The highest level DDC communications network shall be capable of direct connection to and communication with a high speed LAN or WAN utilizing an Ethernet connection. Communication protocol shall be TCP/IP.
2. All PC operator workstations shall have access to point information, command equipment, edit program for any building level network data connected to the Management Level Network without the use of an interposing device.
3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
4. Where indicated on the plans, and when appropriate, any controller residing on the peer-to-peer building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet, as well as, directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network.
6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in an alarm notification at the PC.
7. The Management Level Network shall reside on industry standard Ethernet network utilizing standard TCP/IP communication protocol.
8. Access to the system database shall be available from any workstation on the management level network.
9. All controllers on the Ethernet Management Level Network shall be connected to a virtual local area network as directed by the Owner's Representative.

G. Peer-to-Peer Building Level Network

1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
2. The network shall support a minimum of 100 DDC controllers and PC workstations. Each PC workstation shall support a minimum of 4 peer-to-peer networks hardware or dial up.
3. The system shall support integration of third party systems (fire alarm, security, lighting, Boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control.
4. The peer-to-peer network shall allow the DDC controllers to perform the following functions
   a. Access any data from or send control commands to any other DDC controller or combination of controllers on the network without dependence upon a central or intermediate processing device.
   b. Report alarms in the same manor to any other DDC controller or combination of controllers on the network without dependence upon a central or intermediate processing device.
   c. DDC controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate processing device.
   d. Allow any DDC controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
5. Security controls
   a. The peer-to-peer network shall allow the DDC controllers to assign a minimum of 50 passwords access and control priorities to each point individually.
   b. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for.
   c. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators).
   d. Passwords and priorities for every point shall be fully programmable and adjustable.

H. DDC Controller Floor Level Network

1. The DDC floor level network shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers from transmission of global data.
2. Telecommunication Capability at Server
   a. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator workstations and/or remote terminals via telephone lines, if necessary.
   b. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events. The auto-dial program shall include provisions for handling busy signals, “no-answer” and incomplete data transfers.
   c. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network.
   d. Routines shall be provided to automatically answer calls from remote DDC controllers. The fact that communications are taking place with remote DDC controllers over telephone lines shall be completely transparent to operator at management level.
3. Network design shall include the following provisions
   a. Data transfer rates for alarm reporting and quick point status from multiple programmable controller and Application Specific Controllers (ASC’s). The minimum baud rate shall be 9600 baud.
   b. Support of any combination of programmable controllers and ASC’s. A minimum of 32 programmable controllers and ASC’s shall be supported on a single local network. The buss shall be addressable for up to 32 ASC’s.
   c. Detection of single or multiple failures of ASC’s or the network media.
   d. Error detection, correction, and re-transmission to guarantee data integrity.
   e. Use commonly used, multiple sourced, network components.
   f. Use of industrial standard communication transport such as Ethernet.

2.9 LOCAL CONTROL PANELS

A. Use control panels with suitable mounting brackets for each system. Locate panel adjacent to system served.

B. Fabricate panels of 14 gage furniture grad steel or 6063-T5 extruded aluminum alloy, totally enclosed on six sides, hinged door and key lock, with manufacturer's standard shop painted finish and color.

C. Provide UL listed cabinets for use with line voltage devices. For panels located outdoor, provide NEMA 4 enclosure. When panel located in a corrosive environment, provide NEMA 4R enclosure.

D. Provide control panels for all DDC controllers, ASC's (Application Specific Controllers) and associated function modules. All controls to be in panels except for terminal unit controllers mounted within a UL listed terminal unit equipment enclosure or UL listed VAV box controller designed to be directly mounted on air terminals.

E. Refer to Section 230553 "IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT" for labeling and identification requirements.

2.10 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switches, and test switches, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.11 DIRECT DIGITAL CONTROLLERS

A. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-users, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the point I/O schedule on the contract document. Each controller shall support a minimum of two floor level LAN device network.

B. Each DDC controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system
4. Historical / trend data for all points
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

C. Each DDC controller shall support firmware upgrades without the need to replace hardware.

D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

E. DDC controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

F. The operator shall have the ability to manually override automatic or centrally executed commands at the DDC controller via local, point discrete, on-board hand / off / auto operator override switches for digital control type points and gradual switches for analog control type points.
   1. Switches shall be mounted either within the DDC controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
   2. DDC controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC controllers shall also collect override activity information for reports.

G. DDC controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

H. Each DDC controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587.

J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real time clock and all volatile memory for a minimum of 72 hours.
   1. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention.
   2. Should DDC controller memory be lost for any reason, the user shall have the capability of reloading the DDC controller via the local RS-232C port, via telephone line dial-up or from a network workstation PC.

K. Each DDC control panel shall be provided with an additional 10% for analog inputs and outputs and an additional 20% for digital inputs and outputs in addition to what is shown on the controls drawings.

L. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
   1. Binary Inputs: Allow monitoring of on-off signals without external power.
   2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
   3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
   4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
   5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
   6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
   7. Universal I/Os: Provide software selectable binary or analog outputs.

M. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
   1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

N. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.12 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

A. General: The software programs specified in this section shall be provided as an integral part of DDC controllers and shall not be dependent upon any higher-level computer for execution.

B. Control Software Description

1. The DDC controller shall have the ability to perform the following pre-tested control algorithms
   a. Two-position control
   b. Floating control
   c. Proportional control
   d. Proportional plus integral control
   e. Proportional, integral, plus derivative control
   f. Automatic tuning of control loops

C. DDC controllers shall have the ability to perform any or all the following energy management routines

1. Time-of-day schedule
2. Calendar-based scheduling
3. Holiday scheduling
4. Temporary schedule override
5. Start-Stop Time Optimization
6. Automatic Daylight Saving Time Switchover
7. Night setback control
8. Enthalpy switchover (economizer)
9. Peak demand limiting
10. Temperature-compensated duty cycling
11. Siemens Series 2000 temperature sensor or equal

D. DDC controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC controllers on the network. Database shall support 30-character, English language point names, structured from searching and logs.
2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
3. DDC controller shall provide a HELP function key.
4. DDC controller shall be capable of comment lines for sequence of operation explanation.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC controller shall perform distributed, independent alarm analysis and filtering to minimizing operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC controllers ability to report alarms be affected by either operator or activity at PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point.
   a. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms.
   b. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC controller, etc.) to provide full flexibility in defining the handling of system alarms.
   c. Each DDC controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up.
   d. Users shall have the ability to manually inhibit alarm reporting for each point.
3. Alarm reports and messages will be reported to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully described the alarm condition or direct operator response.
5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data.

1. Trending capability requirements: Any point, physical or calculated may be designated for trending.
   a. Any point, regardless of physical location in the network, may be collected and stored in each DDC controllers point group.
   b. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided.
   c. Each DDC controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of data samples.
   d. All trend data shall be available for use in 3rd party personal computer spreadsheet applications (e.g. Microsoft Excel).
2. DDC controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator selected TID control loops.

G. Loop tuning shall be capable of being initiated either locally at the DDC controller, from a network workstation or remotely using dial-up modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

H. DDC controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points.

2.13 APPLICATION SPECIFIC CONTROLLER (ASC)

A. Each DDC controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level LAN Device Networks.

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as minimum

1. Central System Controllers
2. Terminal Equipment Controllers

C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

D. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

E. Central System Controllers

1. Provide for control of central HVAC systems and equipment including the following:
   a. Chilled water system

b. Heating hot water system
c. Air Handling Units
d. Laboratory Exhaust system
e. Supply and Exhaust fan systems.
f. Boiler Flue Venting system.
g. Packaged Outside Air Unit
h. Domestic hot water system.
i. VRF System.
j. Metering equipment.
k. Plumbing Equipment.

2. Controllers shall include all inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden.
3. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC controller is lost and to insure protection during power outages.
4. All programs shall be field customized to meet the user's exact control strategy requirements. Central system controllers utilizing pre-packaged or canned programs shall not be acceptable.
5. Programming of central system controllers shall utilize the same language and code as used by DDC controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a DDC controller to meet the specified functionality.
6. Each controller shall have connection provisions for a portable operator's terminal. This toll shall allow the user to display, generate or modify all point databases and operating programs.
7. Provide a door mounted interface terminal to allow for direct user access to the controller
   a. The terminal shall provide the user with the following functionality as a minimum
      1) View and set date and time
      2) Modify and override time of day schedules
      3) View points and alarms
      4) Monitor points
      5) Command and modify setpoints
   b. Should the system controller be unable to interface to a door-mounted terminal, provide a laptop or similar terminal at the controller, or provide a DDC controller with a door-mounted or local terminal in lieu of the system controller in order to meet the specified minimum functionality.

2.14 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads 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 minus 10 to plus 70 deg F, 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.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

2.15 WORKSTATION OPERATOR INTERFACE

A. Operator Workstation: One PC-based microcomputer(s) with minimum configuration as follows:
   1. Motherboard: With 8 integrated USB ports (utilizing the more current communication protocols), integrated 10/100 Ethernet network card, integrated audio, bios, and hardware monitoring.
   2. Processor: Minimum performance based upon the minimum requirements for the current version of Microsoft Windows Operating system, plus an additional 50%.
   3. Random-Access Memory: Minimum performance based upon the minimum requirements for the current version of Microsoft Windows Operating system, plus an additional 200%.
   4. Graphics: Minimum performance based upon the minimum requirements for the current version of Microsoft Windows Operating system, plus an additional 50%.
   5. Monitor: 27 inches, LCD color.
   6. Keyboard: QWERTY, 105 keys in ergonomic shape.
   7. Hard-Disk Drive: 500 GB.
   8. DVD-ROM Read/Write Drive
   9. Mouse: Three button, optical, wireless.
   10. Uninterruptible Power Supply: 2 kVa.
   11. Operating System: Most current version of Microsoft Windows Operating System with high-speed Internet access.
   12. Microsoft Office: Full Versions of Word and Excel (most current edition).
   13. Adobe Acrobat: Full Version (most current edition).

B. Basic Interface Description
   1. Provide two licenses to the workstation interface software
   2. The software shall provide, as a minimum, the following functionality
      a. Real time graphical viewing and control of environment
      b. Scheduling and override of building operations
      c. Collection and analysis of historical data and dynamic data (trend plot)
      d. Definition and construction of dynamic color graphic displays
      e. Editing, programming, storage and downloading of controller databases
      f. Alarm reporting, routing, messaging, and acknowledgment.
   3. Application Software:
      a. I/O capability from operator station.
      b. System security for each operator via software password and access levels.
      c. Automatic system diagnostics; monitor system and report failures.
      d. Database creation and support.
      e. Automatic and manual database save and restore.
      f. Dynamic color graphic displays with up to 10 screen displays at once.
      g. Custom graphics generation and graphics library of HVAC equipment and symbols.
      h. Alarm processing, messages, and reactions.
      i. Trend logs retrievable in spreadsheets and database programs.
      j. Alarm and event processing.
      k. Object and property status and control.
      l. Automatic restart of field equipment on restoration of power.
      m. Data collection, reports, and logs. Include standard reports for the following:
         1) Current values of all objects.
         2) Current alarm summary.
         3) Disabled objects.
         4) Alarm lockout objects.
         5) Logs.
      n. Custom report development.
      o. Utility and weather reports.
      p. Workstation application editors for controllers and schedules.
      q. Maintenance management.

4. Provide a graphical user interface, which shall minimize the use of keyboard through the user of a mouse or similar pointing device and “point and click” approach to menu selection. There shall be a minimum of 8 pre-defined function keys to allow quick access to frequently used applications.
5. Application operating requirements:
   a. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously.
   b. EMCS software shall run within the most current version Microsoft operation system. The Windows applications shall run simultaneously with the EMCS software.
   c. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line EMCS alarms and monitoring information.
   d. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows.
      1) Dynamic color graphics and graphic control
      2) Alarm management, routing to designated locations, and customized messages.
      3) Week at a Glance Time-of-Day scheduling
      4) Trend data definition and presentation
      5) Graphic definition and construction
      6) Program and point database editing on-line.
   e. If the software is unable to display several different type of displays at the same time, provide at least two operator workstations.
   f. Report and alarm printing shall be accomplished via Windows program manager, allowing use of network printers.
6. Multi-level password access protection shall be provided to allow the user/manager to limit workstation control, display and database manipulation capabilities as deemed appropriate for each user, based upon an assigned password. A minimum of six levels of access and 50 passwords shall be supported.
7. Operator Activity Tracking – An audit trail report to track system changes, accounting for operator initiated actions, changes made by a particular person or changes made to a specific piece of equipment, designated time frame, shall be printable and archived for future use. The operator activity tracking shall be in a tamper-proof buffer file.
8. Reports shall be generated on demand or via pre-defined schedule and directed to CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports
   a. A general listing of all or selected points in the network
   b. List of all points currently in alarm
   c. List of all points currently in override status
   d. List of all disabled points
   e. List of all points currently locked out
   f. List of user accounts and access levels
   g. List all weekly schedules
   h. List of holiday programming
   i. List of limits and deadbands
   j. Excel reports
   k. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
   l. List of programs
9. Scheduling and Override
   a. Provide a graphical spreadsheet type format for simplification of time of day scheduling and overrides of building operators. Schedules reside in both the PC workstation and DDC controller to ensure time equipment scheduling when PC if off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum
      1) Weekly schedules
      2) Zone schedules, minimum of 200 unique zones
      3) Monthly calendars

10. Collection and Analysis of Historical Data
    a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time.
        1) Trend any system point automatically at time based intervals or change of value, both of which shall be user-definable.
        2) Trend data shall be stored on hard disk for future diagnostics and reporting.
        3) The EMCS shall be capable of archiving trend data to network drives or removable disk media for future retrieval automatically.
    b. Custom report generation.
        1) Trend data report shall allow the user to view all trended point data.
        2) Reports shall be customizable to include individual points or predefined groups of at least six points.
        3) Provide functionality to allow predefined groups of up to 250 trended points to be exported to Microsoft Excel.
        4) Provide custom designed spreadsheet reports for use by Owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environment conditions.
        5) Provide custom reports including creation of data format templates for monthly or weekly reports.
    c. Real Time Trending: provide functionality to view real-time trend data on trend graph displays.
        1) A minimum of six points may be graphed, regardless of whether they have been predefined for trending.
        2) Dynamic graphs shall continuously update point values.
        3) Provide the capability to redefine sampling times or range scales for any point with real time changes in the trending graphs.
        4) Provide the capability to pause the graph and take “snapshots” of screens to be stored on the workstation disk for future recall and analysis. Excel point values may be viewed and the graphs may be printed.
    d. Dynamic Color Graphic Displays
11. Create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including chilled water systems and heating hot water systems, air handling units, fan coil units, VAV terminal boxes, shall be provided as indicated in the point I/O summary of this specification to optimize system performance analysis and speed alarm recognition.
    a. Individual components of each system or piece of equipment shall be represented graphically, including but not limited to pumps, chillers, boilers, fans, and coils.
12. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection to text-based commands.
13. Graphics software shall permit the importing of AutoCAD or Bitmap drawings for use in the system.
14. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations in the graphic display and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
    a. Analog bars in 3 sizes shall be available for monitor and control of analog values, high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to “click and drag” the pointer to change the setpoint.
    b. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
    c. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on / off) or setponit.
15. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
16. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

17. Off the shelf graphic software, Microgafx Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.
18. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.

C. System Configuration and Definition

1. Network wide control strategies shall not be restricted to a single DDC controller, but shall be able to include data from any and all other network panels to allow the development of global control strategies.
2. Provide automatic backup and restore of all DDC controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC controller. Changes made at the DDC controllers shall be automatically uploaded to the workstation, ensuring system continuity.
3. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system backup must be done with the PC workstation off-line, the EMCS contractor shall provide at least 2 operator workstation.

D. Alarm Management

1. Alarm routine shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity, or point type.
2. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The EMCS alarm display screen shall be displayed when the user clicks on the alarm icon.
3. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message.
4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

PART 3 EXECUTION

3.1 ADJUSTMENT AND CLEAN

A. After completion of the installation, regulate and adjust all thermostats, control valves, motors, and other equipment, and place them in complete operating condition. Testing and adjusting of temperature control systems shall be coordinated with all testing, balancing, and adjusting specified and as required by Section 019113 – “COMMISSIONING REQUIREMENTS”.

3.2 SEQUENCE OF OPERATION

A. Provide all automatic control work necessary to accomplish the controls indicated on the Drawings and as described Section 230960. Verify degree and extent of integral control and coordinate with manufacturer to provide for all additional automatic control required to incorporate the equipment into the system in accordance with these sequences.

B. Coordinate all Start/Stop operations with requirements as specified in Division 26 as applicable.

3.3 INSTALLATION

A. General: Install systems and materials in accordance with manufacturer's printed instructions and roughing-in Drawings, and details on Drawings. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these Specifications. Mount controllers at convenient locations and heights.

B. Install control wiring without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with NEC requirements.

3.4 TRAINING

A. Furnish factory trained instructors to give full instruction to Owner personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. Furnish all students with a student binder containing product specific training modules for the system installed. All training shall be held at the Owner's Facilities Building during normal working hours of 7:00 am to 3:30 pm weekdays.

B. Furnish 40 hours of training for the Owner's operating personnel. Training shall be furnished in 2 sessions. The first session shall be 16 hours and shall include basic overview of system operation. The second session shall be 24 hours and scheduled at the end of the warranty period. Training shall include but not be limited to:

1. Explanation of drawings, operations and maintenance manuals
2. Walk-through of the job site to locate control components
3. Operator workstation and peripherals
4. DDC Controller and ASC operation/function
5. Operator control functions including field panel programming
6. Operation of portable operator's terminal
7. Explanation of adjustment, calibration and replacement procedures
8. Student binder with training modules

C. Since the Owner may require personnel to have a more comprehensive understanding of the hardware and software, additional advanced training must be available from the controls contractor and/or manufacturer. If such training is required by the Owner, it will be contracted at a later date.

END OF SECTION

SECTION 230923
INSTRUMENTATION AND CONTROL DEVICES 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 not supplied with factory-wired controls.

B. Work in this section includes instrumentation and control devices, include sensors, valves, actuators, and other equipment and accessories necessary to operate a complete DDC system.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

D. See Commissioning Requirements 019113.

1.2 DEFINITIONS

A. EMCS: Energy Management Control System

B. DDC: Direct digital control.

C. I/O: Input/output.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

1.3 RTD: RESISTANCE TEMPERATURE DETECTOR

A. This specification section defines the minimum requirements for control instrument and devices for a Direct Digital Control (DDC) and Energy Management Control System (EMCS).

B. Work in this section includes furnishing and installing all field devices, including electronic sensors for DDC controls, meters, actuators for motorized control valves and dampers, and all related field wiring, interlocking control wiring between equipment to constitute a complete Energy Management Control System (EMCS).

C. Provide instrument and control devices for the fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control. The installation of the control system shall be performed under the direct supervision of the control manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.

D. All materials and equipment used shall be standard components, regularly manufacture for the specified use and not custom designed especially for this project. All systems components shall have been thoroughly tested and proven in actual use for at least three years.

E. Provide all Energy Management Control System (EMCS) and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all applicable code requirements. All wiring shall be in conduit.

1.4 REFERENCE

A. UL 873 Temperature (and Airflow) indicating Equipment

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's data sheets indicating model number, pressure / temperature ratings, capacity, accuracy, methods and materials of construction, installation instruction, and recommended maintenance. General catalog sheets showing a series of the same device is not acceptable unless other specific model is clearly marked.

   1. Submit manufacturer's specification for each control device furnished, including installation instructions and startup instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked.
   2. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   3. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
   4. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Certificate of calibration and instruction for filed calibration in compliance with Title 24 requirements.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Schematic flow diagram of system show air handling unit, fans, fan coil units, dampers, valves, and other control devices.
      a. Label each device with setting or adjustable range of control.
      b. Indicate all wiring, clearly differentiating between factory and filed installed wiring.
      c. Wiring diagrams shown in schematics shall detail contact states, relay references, etc.
   2. Submit details of construction, layout, and location of each space control device (e.g. thermostat, humidistat, CO2 sensor) within the building, including instruments location in the panel and labeling.
      a. Indicate which piece of mechanical equipment is associated with each device and what area within the building is being served by that equipment.
      b. For terminal unit control, provide a room schedule that would list mechanical equipment tag, room number of space serviced, address of DDC controller, and any other pertinent information required for service.
   3. Schedule of control valves indicating the following:
      a. The system in where the device is to be used, rated capacity, flow coefficient, flow required by device served, actual pressure drop at design flow, size of operator required, close-off pressure, and locations where valves are to be installed.
   4. Wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as required.

D. LEED Submittal

   1. Achievement of LEED-CI v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.6 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates.

B. Qualification Data: For manufacturer.

C. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

D. Field quality-control test reports.

E. Annotated software program documentation shall be submitted for system sequence, along with descriptive narratives of the sequence of operation of the entire system involved.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals.
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   4. Calibration records and list of set points.

B. Submit record drawings to incorporate the EMCS and electric field work.
   1. Revise shop drawings to reflect actual installation. Record actual location of control components, including control units, thermostats, and sensors
   2. Device address list.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique thermostat and positioning relay.
   2. Maintenance Materials: One thermostat adjusting key(s).
   3. One (1) sensor of each type
   4. Two zone thermostats and unit controllers.

1.9 COMMISSIONING

A. Division 23 will be responsible to carry out the Commissioning Requirements specified in 019100 – COMMISSIONING and 230800 COMMISSIONING OF HVAC.

B. Furnish services to completely commission, test and verify the control system and all sensing and monitoring devices including time for on-site services by a control system technician to complete the commissioning scope of work. Control system commissioning shall be coordinated with the Owner’s commissioning activities and Owner’s DDC group.

1.10 QUALIFICATION

A. All control equipment and devices shall be supplied by a company specialized in manufacture of the control equipment and devices of the specified application for at least five years and have proof installation history in the direct digital control system of similar size and complexity as this project.

1.11 QUALITY ASSURANCE

A. Use only UL labeled products that comply with NEMA standards. Electrical components and installation to meet all requirements of electrical specifications of Division 26.

B. Provide devices exposed to outside ambient conditions with weather protection or construct them so that they are suitable for outdoor installation.

C. Provide control devices subject to corrosive environments with corrosion protection or construct them so that they are suitable for use in such environment.

1.12 WARRANTY

A. Manufacturer agrees to repair or replace device that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 2 years from date of Substantial completion.

B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

C. Furnish two major inspections at 6-month intervals and two minor inspections offset equally between the two major inspections. Schedule major inspections in Summer and Winter. Minor inspections shall include visual checks and operational tests of all equipment delivered. Major inspections shall include all work described for minor inspections and the following work:
   1. Clean all equipment, including interior and exterior surfaces.
   2. Perform signal, voltage and system isolation checks of system workstation and peripherals.
   3. Check and calibrate each filed device. Check all analog points and digital points.
   4. Run all diagnostics and correct all previously diagnosed problems.
   5. Resolve and correct any previous outstanding problems.

D. Emergency Service: Owner will initiate service call when the system is not functioning properly. Furnish the Owner’s Representative with the telephone number where service personnel shall be at the building site next business day after receiving a request for service.

1.13 DELIVERY, STORAGE AND HANDLING

A. All handling and storage procedures shall be per manufacturer’s recommendation

B. Control devices shall be kept clean and dry, protected from all damage, including that due to weather and construction traffic.

PART 2 PRODUCTS

2.1 SENSORS AND TRANSMITTERS

A. General
   1. All sensors etc. shall be able to communicate with EMCS for control, monitoring, and report.

B. Manufacturers (except where noted)
   1. Vaisala.
   2. Onicon.
   3. Ebtron.
   4. Or equal.

C. Temperature Sensor (all public spaces)
   1. Platinum or nickel RTD, have a base resistance of 1000 ohm at 70 degrees F. 100 ohm platinum RTD are acceptable if used with temperature transmitters.
   2. Thermistor shall be 10,000 ohm.
   3. Outside air sensors shall be shielded from solar radiation by both installation location and finned radiant energy rejection container.
   4. Temperature sensors used in BTU calculations shall be a matched pair with a differential accuracy of ±0.15 degrees F over entire range and supplied by the BTU system manufacturer.
   5. RTD Sensor

Accuracy (Room Sensor Only)	minimum ±0.5 degrees F
Accuracy (Averaging)	minimum ±0.6 degrees F
Range	minimum 30 to 100 degrees F

   6. Thermistor

Accuracy (All)	minimum ±0.36 degrees F
Range	minimum 0 to 150 degrees F
Heat Dissipation Constant	minimum 2.7 mW/°C

   7. Temperature Transmitter

Accuracy	minimum ±0.1degrees F or ±0.2% of span
Output	4-20mA

   8. Use averaging elements on duct sensors when the ductwork is ten square feet or larger.

9. All mixed air and heating coil discharge sensors shall have averaging elements regardless of duct size.
10. In piping systems use temperature sensors with separable wells designed to be used with temperature element.

D. Humidity Sensor
   1. General
      a. Capacitive thin-film polymer sensor types with a range of 0-100%RH
      b. Accuracy: +/-2%
      c. Stability: less than 0.5% drift per year
      d. Temperature effect: less than 0.005% per degree F.
   2. Outdoor
      a. Use sensor designed for outside air use along with weather enclosure.

E. Pressure Sensor/Transducer (for air system)
   1. Manufacturers
      a. Duct Mounted Applications (VAV): Vaisala, Kele, Honeywell or equal.
      b. Outdoor Static Pressure Monitoring: Vaisala model SPH10 with PTB210 pressure transducer or equal for outside air reference.
   2. Provide transmitter that operates on the capacitance principle and is capable of sensing low positive, negative, or differential pressures.
   3. Transmitter shall have minimum of three pressure ranges adjustable by an on-board switch or jumper. Size the transmitter where the middle or high range is suitable for the application. (do not need adjustable range for VAV box application)
   4. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions.
   5. Transmitter shall be provided with an integral four-digit display of the pressure sensed (do not need display for VAV box application)
   6. Performance Requirement
      a. Duct Mounted Applications (VAV Control)

Accuracy	+/-1% full scale
Compensated Temperature Range	32 to 140°degrees F
Temperature Effect	0 – 1 inches w.g. range 0.9% full scale/°F >1 inches w.g. range 0.01% full scale/°F
Stability	0 – 1 inches W.G. range: 2.0% max. drift per year 0 – 10 inches W.G. range: 0.5% max. drift per year
Output	4-20mA
Load Impedance	800 ohm minimum
Operating Temperature	32°F to 140°F degrees F

F. Differential Pressure Switch (for Air Systems)
   1. Manufacturers
      a. Cleveland Controls
      b. Or equal.
   2. Low Pressure Applications (less than 2 inch W.C. (500 Pa))
      a. Performance

Setpoint Pressure Range	0.05 to 2.0 inch W.C
Compensated Temperature Range	-40 to 140 degrees F
Operating Temperature	-40 to 140 degrees F

b. Typical Applications
   1) Filter Differential Pressure Switch
3. Standard Pressure Applications (0.4 to 12 inch W.C.)
   a. Performance

Setpoint Pressure Range	0.4 to 12.0 inch W.C. (100 to 3 000 Pa)
Compensated Temperature Range	-40 to 140 degrees F (-40 to 60 degrees C)
Operating Temperature	-40 to 140 degrees F (-40 to 60 degrees C)

   b. Typical Applications:
      1) High Static Discharge Alarm
      2) Low Static Alarm
      3) Fan Differential Pressure

G. Current Sensor
   1. Provide a current sensor with adjustable threshold and digital output with LED display, Veris H-708/H904 or equal.
   2. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives.
   3. When used on variable speed motor application, use a current sensor that will not change state due to varying speeds.

H. Carbon Dioxide (CO2) Sensor
   1. Carbon Dioxide sensor shall utilize non-dispersive infrared (NDIR) technology.
   2. The sensor shall have an automatic calibration algorithm that will compensate for sensor drift over time due to sensor element degradation.
   3. Device shall be provided with a 0-10VDC or 4-20mA analog output that is selectable and a field adjustable relay alarm output.
   4. The sensor shall be user calibrated with a minimum calibration interval of five years.
   5. Performance

Range	0 – 2000 ppm CO2
Accuracy	+/-2% full scale (±30ppm)
Response Time	< 1 min.
Compensated Temperature Range	32 to 250 degrees F
Temperature Effect	0.03% full scale / °F
Stability	0.5% max. drift per year
Output	4-20mA
Load Impedance	600 ohm minimum
Operating Temperature	55 to 113 degrees F

   6. Wall Mounted
      a. Provide with built in CO2 level display

2.2 THERMOSTATS

A. Thermostat shall have numeric temperature setpoint in degrees range from 55 to 85 degrees F with accuracy of ± 0.5 degrees F.

B. Thermostat shall have setback capability to program up to four time and temperature settings per schedule.

C. Thermostat shall have capability of automatic change over for heating and cooling.

D. Furnish fan override switch with three speed fan controls.

E. Space Thermostats

  1. All room thermostat in non-public spaces shall have exposed setpoint adjustment with internal stops or software stops for minimum and maximum setting initially set between 68 to 76 degrees F.
  2. All room thermostats in public areas will have concealed setpoint adjustment with blank cover. Setpoint stops shall be accessible only to authorized personnel, to restrict over-heating or over-cooling.

2.3 ELECTRONIC VALVE ACTUATOR

A. Manufacturers

  1. Danfoss.
  2. Or equal.

B. Provide all control valves as shown on the drawings and as required to perform function specified in sequence of operation.

C. Direct mounted, self-calibrating type designed for a minimum 60,000 full stroke cycles at rated force and shall be from the same manufacturer as the pressure independent control valve.

D. Size for torque required for valve close off at 150 percent of total system (head) pressure for two-way valves; and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.

E. Actuator shall allow smooth and position operation of devices served and to provide sufficient torque capacity for tight shutoff against system temperature and pressure encountered.

F. Full proportional actuator use 0-10VDC inputs and zero and span adjustment.

G. For two position actuator use 24VAC, 120VAC actuator may be used for hardwire interlock.

H. Actuator for applications other than terminal units shall be provided with a manual override capability.

I. Actuator shall be provided with a visible position indicator and shall possess a 2-10V DC position feedback signal allowing the EMCS to read the exact position of the valve and provide information for EMCS algorithm to calculate the exact flow rate through the valve with accuracy +/- 5%.

J. Actuator shall have automatic reset button compatible with the valve to automatically recalibrate the 0-10 V input/output signal to match the maximum high limit flow set on the valve.

K. Provide spring-return for application involving moisture protection or specified normally open/close operation.

L. Valves shall move to their fail positions on loss of power to the actuator.

M. Provide actuators with linkages and brackets for mounting on device served.

N. Coupling: Directly couple end mount to stem, shaft, or ISO-style direct-coupled mounting pad.

O. Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to deactivate the actuator at the end of rotation.

P. Fail-Safe Operation: Electronic fail safe shall incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10o increments. The electronic fail safe shall have a 2 second operational delay.

Q. Temperature Rating: -22 to 122 degrees F.

R. Housing: Minimum requirement NEMA type 2 / IP54 mounted in any orientation.

S. Agency Listing: ISO 9001, cULus, and CSA C22.2 No. 24-93.

2.4 ELECTRONIC DAMPER ACTUATOR

A. Manufacturers
   1. Belimo.
   2. Honeywell.
   3. Or equal.

B. Size operators for smooth and positive operation of devices serve, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered.

C. Damper actuator shall be located outside of air stream unless otherwise indicated such as on fire damper. In no case shall damper actuator for fume exhaust system be located in the air stream or require entering the air stream to service an actuator.

D. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.

E. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

F. Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.

G. Fail-Safe Operation: Mechanical, spring-return mechanism. Electronic fail safe shall incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10 degree increments. The electronic fail safe shall have a 2 sec operational delay.

H. Power Requirements (Spring Return): 120 V-ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc.

I. Full proportional actuator use 0-10VDC inputs and zero and span adjustment.

J. Proportional Actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable by use of external computer software Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload and mechanical travel. Programming shall be through an EEPROM without the use of actuator mounted switches.

K. For two position actuator use 24 VAC, 120 VAC actuator may be used for hardwire interlock.

L. Temperature Rating: -22 to 122 degrees F.

M. Housing: Minimum requirement NEMA type 2 (4/4X) / IP54 (IP67) mounted in any orientation.

N. Actuator stroke time shall match the requirements of the DDC controller for proper operation.

O. All electric actuator will be provided with overload protection to prevent motor from damage when stall application involving fire, moisture protection or specified normally open/close operation.

P. Provide damper end switch with dry contact where control sequences require damper position indication. End switches shall not contain mercury.

Q. Provide operators with linkages and brackets for mounting on device served.

R. Agency Listing: ISO 9001, cULus, and CSA C22.2 No. 24-93.

S. Actuator to have manual override capability.

2.5 CONTROL VALVES

A. Manufacturer
   1. Danfoss AB-QM.
   2. Or equal.

B. Pressure independent globe type valve.

C. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

D. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional (except as noted).

E. Pressure Independent Temperature Control Valves
   1. Factory fabricated pressure independent with internal differential pressure regulator consisting of EPDM diaphragm, stainless steel spring and pressure control disc which automatically adjusts to normal changes in system pressure providing 100 percent control valve authority at all positions of the valve. Valve shall be globe type to maintain a linear flow characteristic, accurately controlling flow from 0-100 percent full rated flow with an operating pressure differential range of 3 to 60 psi. Valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01 percent of valve Kv). Unless otherwise specified or shown, valves shall be two way pressure independent globe-style bodies. Hydronic system pressure independent control valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure.
   2. NPS 2 and smaller: Class 150 bronze or brass body with union connections, stainless steel trim, stainless steel rising stem, stainless steel disc, and screwed ends with backseating capacity repackable under pressure.
   3. NPS 2-1/2 and larger: brass or bronze body, stainless steel trim, stainless steel rising stem, stainless steel disc, flanged ends with backseating capacity repackable under pressure
   4. Sizing
      a. Valve manufacturer shall provide ½” to 10” valves. Valves shall be from single manufacturer.
      b. Two position: shall be based of flow and line sized.
   5. Close-Off Pressure Rating: 125 psi for valves under NPS 1 1/4 and smaller and 250 psi for NPS 1 1/2 and larger.
   6. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory with a single screw on a four-way DIN mounting-base.
   7. Valves NPS 1 1/4 and smaller for individual coil control shall be provided as part of a pipe package including the following. All components shall be factory assembled.
      a. The supply side of the coil shall contain a strainer/shut-off ball valve/drain, manual air vent with a P/T port.
      b. The return side of the coil shall contain a union fitting with a P/T port, characterized control valve, an integrated manual balancing valve/union/isolation ball valve/manual air vent with P/T port.
      c. Shut-off valves as an integrated part of the characterized control valve are prohibited.
      d. For 3-way installations, supply an integrated 100 percent port isolation valve/manual air vent with a P/T port for field installation in the bypass of the circuit.
      e. A 24 inches stainless steel flexible hose set shall be provided for each coil supply and return connection for all pipe packages.
   8. Valve must maintain flow accuracy under 5% from 0-100% full rated flow with an operating pressure differential ranging from 5-60 psig for valve sizes NPS ½ to NPS 1-1/4, 4-60 psi for size NPS 1-1/2 to NPS 10, and 2.3 to 60 psi for NPS ½ low flow valve.

F. Control valve to have manual override capability.

2.6 GENERAL AIRFLOW MEASURING STATIONS

A. Airflow station shall be thermal dispersion type by Ebtron or equal for the following application
   1. Duct and plenum mounted airflow and temperature measurement device
   2. Fan inlet mounted airflow measurement devices

B. Pitot tubes and arrays are not acceptable.

C. Vortex shedding devices are not acceptable.

D. Provide airflow measuring station where indicated on the plans.

E. Furnish installation and maintenance instruction from manufacturer and install the airflow station accordingly.

F. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
   1. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes shall demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

G. Submit airflow measuring station schedule detailing the airflow range to be measured, corresponding velocity pressure, differential pressure transducer range, and airflow station size.

H. Provide access door to airflow station for maintenance.

I. Each airflow measuring station shall consist of one or more sensor probes and a single, remotely mounted, microprocessor based transmitter capable of independently processing up to 16 independently wired sensor nodes contained in one or more probe assemblies per measurement location.

J. The maximum allowable pressure loss through the station shall not exceed 0.085-inch w.c. at 1000 fpm, or 0.15-inch w.c. at 2000 fpm. Each station shall be capable of measuring the airflow rate within an accuracy of 2 percent as determined by U.S.G.S.A. certification tests. The station(s) shall have a self-generated sound rating of less than NC 40, and the sound level within the duct shall not be amplified.

K. All Sensor Probes
   1. Each sensor node, consisting of two thermistor-sensors and their structural housing, shall independently determine the airflow rate and temperature at each measurement point.
   2. Each sensor node shall be factory calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST). Thermistor sensor calibrations traceable only to temperature standards are not acceptable.
   3. Airflow Accuracy: +/- 2% of reading over entire operating airflow range
   4. Temperature Accuracy: ±0.25 degrees F over the entire operating temperature range of -20 to 160 degrees F.
   5. Relative Humidity: 0 to 99% (non-condensing) operating humidity range for each sensor probe. Product design shall consider direct exposure to or emersion in liquid water and temporary exposure shall not damage the sensing element.
   6. Single source responsibility for airflow temperature measuring probes and transmitter for each airflow measurement station.

L. Duct and Plenum Probes
   1. Probes shall be constructed of extruded, gold anodized 6063 aluminum tube or type 316 stainless steel tubes. Al internal wires within the tube shall be Kynar coated. PVC insulated conductors are not acceptable.
   2. Probe Sensor Density shall be as below:

AREA (SQ. FT)	SENSORS
≤1.5	**2**
>1.5 AND <4	**4**
4 AND < 8	**6**
8 AND < 12	**8**
12 AND < 16	**12**
≥16	**15**

3. Sensor probe design shall be capable of providing up to 8 sensor nodes per probe.
4. The minimum operating airflow range shall be 5,000 FPM (0 to 25.4 m/s) unless otherwise indicated on the plans
5. Each ducted sensor probe shall have an integrated UL listed, plenum rated cable. Cable jackets and conductor insulation shall be FEP, Teflon-FEP or Neoflow-FEP. Cables shall include a terminal plug for connection to the remote mounted transmitter. All terminal plug interconnecting pins shall be gold pated. PVC jacketed cables or PVC insulated conductors are not acceptable with ducted sensor probes.

M. Fan Inlet Probe
1. Sensor node assemblies shall be mounted on Type 304 stainless steel housing.
2. Mounting rods shall be filed adjustable to fit the fan inlet and constructed of zinc plated steel.
3. Identify mounting style as “face mount” or “throat mount”.
4. Face mount style shall provide no mechanical fastening in the throat or on the surface of the inlet cone and shall be used on all inlet condition sensitive plenum type or plug fans.
5. Mounting feet shall be constructed of Type 304 stainless steel.
6. The minimum operation airflow range shall be 10,000 FPM unless otherwise indicated on the plan.
7. Fan inlet probe cables shall be UL plenum rated and may be FEP or PVC jacketed.

N. Transmitter
1. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor node.
2. The transmitter shall be capable of filed configuration and diagnostics using an on-board pushbutton interface and LCD display.
3. The transmitter shall have an on-off power switch and operate on 24 VAC. Isolation transformers shall not be required.
4. The transmitter shall use a switching power supply, fused and protected from transients and power surges.
5. The transmitter shall use “watch-dog” circuitry to assure automatic reset after power disruption, transients and brown outs.
6. All interconnecting pins, headers and connection so n the main circuit board, cards and cable receptacles shall be gold plated.
7. The operating temperature range for the transmitter shall be -20 to 120 degrees F. The transmitter shall be installed at a location that is protected from weather and water.
8. The transmitter shall be capable of communicating with other devices using one of the following interface options:
   a. Linear analog output signals for airflow and temperature. Filed selectable, fuse protected and electrically isolated from all other circuitry, 0-5VDC/0-10VDC/4-20mA (4-wire)
   b. Field Selectable LonTalk, BACNet-MS/TP, BACNet-ARCNET: Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a MS Windows based PC.

9. The transmitter shall be capable of providing an infra-red interface for manually downloading transmitter configuration data using a handheld PDA
10. Provide PDA upload/download software for multiple users.
    a. Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter
    b. Upload software shall be capable of displaying and saving all setup parameters that can be configured using the on-board pushbutton interface and LCD display.
11. Provide a Microsoft Excel file capable of creating test and balances reports from PDA dat files transferred to a Window based PC.
12. Provide a Microsoft Excel file to create configuration data files that can be transferred from a Window based PC to a PDA for upload to one or more transmitters.
13. Provide transmitter that will average up to sixteen sensors and provide two filed selectable linear analog output signals (4-20 mA and 0-10 VDC) proportional to airflow and temperature. Sensor electronic circuitry other than the temperature sensors shall not be exposed to the air stream and shall be protected from moisture to prevent failure.

2.7 ELECTRONIC AIRFLOW TRANSMTTERS

A. The transmitter shall be capable of receiving flow signals (total and static pressure) from an airflow station or probe array and produce dual outputs linear and scaled for air volume, velocity, differential pressure, etc.

B. The transmitter shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output during normal operating mode. All transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling will be performed digitally in the on-board microprocessor via input push-buttons.

C. The transmitter will be available in multiple natural spans covering the range of 0.05 to 10.0 inches W.C. with an accuracy of plus or minus 0.25 percent of natural span. The transmitter shall be furnished with a transducer automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 10 to 1 velocity (100 to 1 pressure) turndown.

D. The transmitter shall be the VELTRON II as manufactured by Air Monitor Corporation or equal.

E. Provide Digital Output for connection to Building Control System for flow totalization.

2.8 TERMINAL UNIT ACTUATORS

A. Manufacturers:
   1. Belimo
   2. Or equal.

B. Close-Off (Differential) Pressure Rating: 200 psi.

C. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle or an ISO-style direct-coupled mounting pad.

D. Power Requirements: 24V-ac/dc.

E. Temperature Rating: -22 to 122 degrees F.

F. Housing Rating: Minimum UL94-5V(B) flammability.

G. Agency Listing: CE, UL 60730-1A/-2-14, CAN/CSA E60730-1, CSA C22.2 No. 24-93, CE according to 89/336/EEC.

PART 3 EXECUTION

3.1 INSTALLATION

A. All wiring shall be in conduit. Conduit shall be run parallel or perpendicular to walls and building lines.

B. Wires shall be labeled with a plastic permanent label with minimum 1/8” sized letters (hand written label not acceptable) at junction point to each apparatus point of connection.

C. Wiring shall not use the voice/data wire way/ conduit systems as pathways.

D. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation.

E. Locate room thermostats and sensors align with light switches and carbon dioxide sensor. Standard mounting height will be 48 inches, required height for ADA compliance.

F. For drywall installation, room sensor mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.

G. Any room thermostats or sensors mounted on an exterior wall shall be mounted on a thermally insulated sub-base. Sub-base to provide a minimum of one half inch of insulation.

3.2 LABELS AND TAGS

A. Provide labels for all field devices including sensors, meters, transmitter and relays. Labels shall be plastic laminate with letter not less than 1/2-inch and located adjacent to the device.

B. Junction box covers shall be painted yellow and labeled “EMCS”.

3.3 TESTING

A. When installation is complete, the Contractor shall perform the following:

1. A 100 percent filed calibration of all sensors and equipment. Calibration of sensors and control devices shall in compliance with Title 24 requirements.
2. Verify of each control point by comparing the control demand and the field devices.

END OF SECTION

SECTION 230960
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Variable Volume Air Handling Unit (AHU-1, AHU-2)

B. Variable Volume Air Handling Unit (AHU-3)

C. Constant Volume Package Unit (PAC-1)

D. Lab Exhaust Fans (EF-1, EF-2, EF-3, EF-4)

E. Non-Hood Rooms

F. VAV Hood Rooms

G. Chilled Water System

H. Heating Hot Water System

I. Zones Control

J. Fan Systems

K. Miscellaneous Systems

1.2 SYSTEM DESCRIPTION

A. This Section defines the manner and method by which the controls function. Requirements for each type of control system operation are specified. Equipment, devices and system components required for control systems are specified in other Sections.

1.3 RELATED SECTIONS

A. Section 019113 – COMMISSIONING REQUIREMENTS.

B. Section 015719 – CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT.

1.4 SUBMITTALS

A. Submit diagrams indicating the mechanical system controlled and all control system components. Label with settings, adjustable range of control and limits. Include written description of control sequence referencing all labeled devices and equipment.

B. Include flow diagrams for each control system, graphically depicting control logic.

C. Meet with the Owner's operations personnel or appointed representative to formulate the graphic representation of the control systems and displayed information. As a minimum, the mechanical system components, control system components, and controlled function status and values shall be displayed.

1.5 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Section 016000.

B. Accurately record actual setpoints and settings of controls, including changes to sequences made after submission of shop drawings. Record drawings shall indicate all control device locations.

1.6 SYSTEM STARTUP

A. After a power outage, the control system shall reset to the last operating condition and re-energize equipment based upon the following schedule. Each piece of equipment shall be energized with a 1 minute (adj.) delay between equipment starts:

1. Air Handling Unit

2. Exhaust and Supply Fans

1.7 LEED

A. This project is required to achieve certification under LEED-NC v 2009. Please review the LEED Requirements Section 01 8113 of this Specifications Manual.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 VARIABLE VOLUME AIR HANDLING UNIT (AHU-1, AHU-2)

A. General: Air handling unit shall consist of supply and return fans, final filter, cooling and heating coils and economizer mixing box.

B. Air handling unit shall be on emergency power.

C. Indoor Design Temperature Criteria: 76 degree F (summer) and 68 degree F (winter).

D. Operational Schedule

1. Unit will run 24/7 and energized through the energy management control system (EMCS) in the automatic mode. AHU operation divided into occupied and unoccupied modes. AHU shall run during unoccupied mode to supply make-up air for laboratories which are continuously exhausted.

a.	Weekday :	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
b.	Saturday:	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
c.	Sunday:	12:00 a.m. to 11:59 a.m.	Unoccupied
d.	Holiday:	12:00 a.m. to 11:59 a.m.	Unoccupied

2. Provide capability for a time based override of 1 hour (adj.). The override time shall be variable between 1 and 4 hours. Upon receiving an override signal from a variable air volume thermostat, the air handling unit shall operate in override mode for the scheduled override time (1 hour, adj.).
3. During occupied mode, the space temperature will be maintained per setpoint. An individual laboratory space may become unoccupied during lunch time or any other event. When the space becomes unoccupied, the space occupancy sensors will inform the EMCS that the space is unoccupied and the space air circulation will be reduced to 4 air changes as long as the space is unoccupied. Temperature setpoint is maintained.
4. After-hours Operation past Occupied hours
   a. The air handling unit associated with the after-hours zone shall resume occupied mode setpoints to provide air conditioning to meet cooling/heating demand setpoint (setpoint at minimum 6 air changes per hour).
   b. Exhaust fans associated with the energized air handling unit shall remain on.
   c. The unit shall continue to operate in after-hours mode for 1 hour (adj.) OR when the occupancy sensor detects no occupants in the space for more than 30 minutes, the zone shall go back into unoccupied hours set back controls.
5. Unoccupied Hours Operation
   a. The air handling unit shall run and continuously supply laboratory spaces at 4 air changes per hour and other VAV boxes set to minimum airflows.
   b. Exhaust fans associated with the air handling unit shall remain on.
   c. The outside air minimum damper shall remain open. Outside air modulating damper shall be closed.
   d. Cooling required during unoccupied mode:
      1) The supply air discharge temperature shall be set to 65°F (adj.)
      2) The economizer cycle shall be utilized when conditions permit as outlined in the economizer sequence of operations, otherwise the outside air dampers shall remain closed.

    e. Heating required during unoccupied mode:
        1) The supply air discharge temperature shall be set to 85°F (adj.)
        2) The outside air dampers shall remain closed.

E. Variable Frequency Drive Operating Modes

1. Hand Position: Fan shall run bypassing all control interlocks, all safety interlocks shall be satisfied (high static, fire alarm).
2. Off Position: Fans shall not run.
3. Auto Position: Fans shall run provided all safety provisions are satisfied.

F. Monitor

1. Supply Fan Status: The VFD shall report supply fan status via network card and current sensing relay to the EMCS.
2. Supply Fan Speed: The VFD shall report the supply fan speed to the EMCS.
3. Outside Airflow: The outside airflow measuring station shall report the outside airflow to the EMCS.
4. Supply Fan Airflow: The supply air airflow measuring station shall report the supply airflow to the EMCS.
5. Return Fan Status: The VFD shall report return fan status via network card and current sensing relay to the EMCS.
6. Return Fan Speed: The VFD shall report the return fan speed to the EMCS.
7. Return Fan Airflow: The return air airflow measuring station shall report the supply airflow to the EMCS.
8. Return Air Temperature: The return air temperature sensor shall report the return air temperature to the EMCS.
9. Mixed Air Temperature: The mixed air temperature sensor shall report the mixed air temperature to the EMCS.
10. Filter Status: The differential pressure sensor shall report the filter pressure drop to the EMCS.
11. All Valve Positions: Valve positions shall be reported via the control valve commanded position to the EMCS.
12. All Damper Positions: Damper positions shall be reported via the damper actuator commanded position to the EMCS.

G. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply Air Fan VFD Status OR VFD Alarm	Supply Air Fan Failure	Shut down supply air fan
One	Return Air Fan VFD Status OR VFD Alarm	Return Air Fan Failure	Shut down return fan
One	Supply Air discharge static pressure exceeds 3.5 inches W.C. (adj.)	Supply Air Fan High Static	Shut down AHU
One	Return Air discharge static pressure exceeds 2.5 inches W.C. (adj.)	Return Air Fan High Static	Shut down AHU
Two	High zone temperature	High Zone Temperature	None – notification only.
Two	Low zone temperature	Low Zone Temperature	None – notification only.
Two	High zone static pressure	High Zone Static Pressure	None – notification only.
Two	Low zone static pressure	Low Zone Static Pressure	None – notification only.
Two	Any valve command does not match status (alarm shall specify failed valve)	Valve Failure (showing name of alarmed valve)	None – notification only.
Two	Filter bank pressure differential exceeds 1-inch W.C.	Filter High Static	None – notification only.
Two	Any damper actuation failure (alarm shall specify failed damper)	Damper Failure (showing name of alarmed damper	None – notification only
Two	Outside airflow falls 10 percent below minimum for 5 minutes (adj.)	Low Ventilation Air	None – notification only

H. Fire Alarm Control

1. Activation of the duct detector in the fan discharge ductwork shall trigger a fire alarm. Fire alarm shall shutdown supply and return fans and close outside air dampers after 120 seconds when the alarm is activated to allow occupants to get out of the laboratory spaces which are kept at negative pressure. The wiring and conduit from the duct detector for fan shut down shall be provided.
   a. Supply Fan: OFF as controlled by fire alarm.
   b. Return Fan: OFF as controlled by fire alarm.
   c. Outside Air (Minimum) Damper Position: CLOSED as controlled by fire alarm.
   d. Outside Air (Modulating) Damper Position: CLOSED as controlled by fire alarm.
   e. Return Air Damper Position: CLOSED as controlled by fire alarm.
   f. Exhaust Air Damper Position: OPEN as controlled by fire alarm.

I. Supply Air Temperature Control

1. The discharge air temperature shall signal the EMCS to modulate water flow to maintain discharge air temperature setpoint of 55°F (adj.)
2. The supply air temperature shall be reset from 55°F to 60°F (adj.) based on supply air temperature reset.
3. Supply air temperature reset
   a. During occupied mode, the supply air set point shall be reset from 55°F when outdoor temperature is 70°F (adj.) and above, proportionally up to 60°F (T-max) when outdoor air is 60°F and below.
   b. T-max shall be reset using trim and respond logic.
      1) While fan is proven on, increase setpoint by 0.2°F, every 5 minutes, if there are 3 (adj) or fewer zone cooling requests.

2) If there are 3 (adj.) or more cooling requests decrease the setpoint by 0.2°F. A cooling request is generated when the cooling loop of any zone served by the system is greater than 99%.

c. Restrooms, corridors and storage space zones should be excluded from any reset schedule reference tables.

J. Supply Fan Static

1. Supply fan speed will modulate to maintain duct static pressure as described below

a. The static pressure setpoint will be reset based on the highest zone pressure demand. The low/high static reset setpoints will be established by the test and balance contractor. The system will be programmed at startup with the following adjustable numbers;

Low Static Setpoint (LS-SP)	0.5 in WG
High Static Setpoint (HS-SP)	1.5 in WG

b. Upon confirmed fan status, the supply fan VFD will be ramped up to meet the HS-SP. Once the setpoint is reached the VFD will be modulated to the meet the reset static pressure setpoint (RSP-SP).

c. Duct Pressure Reset Schedule

1) Static pressure setpoint shall be reset using trim and respond logic within the range shown above (to be confirmed by TAB contractor). When fan is off, setpoint shall be at minimum value.

2) When fan is proven on, decrease set point by 0.05” WC every 2 minutes, if there are 2 (adj.) or fewer pressure requests. If there are more than 2 (adj.) pressure requests, increase the set point by 0.05” WC.

3) The EMCS shall poll the position of each VAV terminal unit damper every 3 minutes (adj.).

4) The position of each damper shall be reported by the VAV controller.

5) Pressure request is generated when any VAV terminal unit served by the system is 85% open.

d. Restrooms, corridors and storage space zones should be excluded from any reset schedule reference tables.

2. If at any time the duct static pressure measured at the high limit safety trip in the unit exceeds the duct static HS-SP, the inline mechanical high static safety switch will open and shut down all the associated fans. A high static alarm will be generated by way of an auxiliary set of contacts on the safety switch. The unit must be manually reset at the switch. The switch will be mounted in the control panel on exterior locations and adjacent to the control panel in indoor locations and where the control panel is mounted inside an access door on the AHU.

K. Outside Ventilation Air Control

1. Economizer Control

a. Monitoring

1) Reference outside air dry bulb temperature in °F.

2) Common return air dry bulb temperature in °F.

b. Operation

1) The controller shall modulate the outside air modulating, relief and return dampers in sequence to maintain the mixed air temperature setpoint 2°F (adj.) less than the discharge air temperature setpoint.

(a) The economizer shall be enabled whenever:

(i) Outside air temperature is less than 74°F (adj.).

(ii) AND outside air dry bulb temperature is less than the common return air dry bulb temperature.

(iii) AND the supply fan status is on.

(iv) AND outside air relative humidity is less than 80% (adj.).

2) When the unit is started in occupied mode and outside air temperature is less than 40°F (adj.), the modulating outside air damper shall ramp open to its minimum set point over a 5 minute (adj.) period and the economizer PID calculation shall be disabled. Only after this period shall the economizer PID output start calculating. When OAT is >40°F, there shall not be a delayed ramp open period.

3) When economizer is enabled, the following operations shall be allowed to occur as needed and in the order listed to achieve mixed air temperature setpoint:
(a) First, outside air minimum damper shall fully open.
(b) Then, the outside air modulating damper shall modulate from closed to full open.
(c) Then, the return air damper shall modulate to fully closed. Economizer PID output shall continue to reset return damper from its controlled modulated position to achieve minimum OA and plenum pressures to fully closed, 0% open.
(d) Relief damper shall fully open.
4) The outside air modulating damper shall close and the return air damper shall open when:
(a) Mixed air temperature drops from 50°F (adj.) to 45°F (adj.).
(b) OR loss of supply fan on status.
(c) OR if unit is commanded off.

2. Demand Control Ventilation
a. Monitoring
1) Zone carbon dioxide levels in parts per million. Does not apply to all zones refer to plans for specific locations.
2) Outside ventilation airflow rate. (in cubic feet per minute).
3) Maximum allowable CO_2 levels: equal to outside air CO_2 concentration plus 600 ppm. This level shall be measured at 5 min. (adj.) intervals.
b. Operation
1) When not in economizer mode, unit shall operate at the demand control ventilation (DCV) minimum setpoint as indicated in the schedules with outside air minimum damper in open position.
2) If any zone air carbon dioxide levels reach the maximum allowable CO_2 levels, the modulating outside air damper shall begin to open.
3) The outside air modulating damper shall modulate from the DCV minimum setpoint to the maximum design outside air ventilation rate. The damper shall increase the outside air flow rate 10 percent (adj.) of the differential between maximum design outside air ventilation rate and DCV minimum setpoint every 1 minute (adj.).
4) If CO_2 level continues to be above maximum level the damper shall continue to open up to the maximum design outside air flowrate.
5) Once all zones are less than the maximum allowable CO_2 level the modulating outside air damper shall not open further. The damper shall remain at this flow rate until the CO_2 concentration in all zones drops below OSA concentration plus 500 ppm (adj.).
6) Once the CO_2 concentration for all zones drops to outside air CO_2 concentration plus 400 ppm (adj.), the modulating outside air damper shall close.

L. Return Fan Control
1. The return fan speed shall be modulated to maintain an average zone pressurization of 0.01” w.c. (adj.) greater than the exterior reference pressure.
2. Variable speed drive shall be provided with a direct connection to the EMCS for monitoring and commanding the variable speed drive points from the EMCS workstation.

M. Morning Flush Control
1. Monitoring
a. Return air temperature
2. Operation
a. Prior to scheduled occupancy the air handling unit shall operate in 1 hour (adj.) flush mode followed by a warm up mode. In the flush mode the unit shall supply the minimum design outside ventilation air.
b. The supply air temperature setpoint shall be set to 55°F (adj.).

N. Morning Warm-Up
1. Morning warm-up shall run when the lowest indoor air temperature is less than 65°F (adj.).
2. The system shall be set to with the outside air modulating damper closed and outside air minimum damper open. The chilled water valve shall be closed.
3. SAV/VAV boxes and reheat coil control valves shall remain fully open until the space temperature setpoint of 68°F (adj.) is achieved and then will modulate to maintain the space temperature setpoint.

4. System shall operate in this mode until internal temperatures setpoints are met at which point VAV boxes and air handling unit shall revert to normal operation.

O. Valve Failure Configuration

1. Actuation for the modulating outside air dampers shall be fail closed.
2. Actuation for minimum outside air damper shall be fail open.
3. Actuation for return air damper shall be fail open.
4. Actuation for the chilled water control valve shall be fail open.
5. Actuation for the heating hot water control valve shall be fail open.
6. Actuation of the exhaust air damper shall be fail open.

P. Minimum Requirements for Operator Workstation Display

1. Supply fan VFD status
2. Supply fan VFD fault
3. Supply fan VFD by-pass
4. Supply fan on-off status
5. Supply fan speed
6. Supply fan static pressure setpoint
7. Supply fan static pressure (actual)
8. Supply fan high static pressure
9. Supply air airflow
10. Supply air temperature
11. Supply air temperature setpoint
12. Supply air downstream static pressure
13. Smoke Detector status
14. Return fan VFD status
15. Return fan VFD fault
16. Return fan VFD by-pass
17. Return fan on-off status
18. Return fan speed
19. Return fan high static pressure
20. Return air airflow
21. Return air temperature
22. Return air modulating damper position
23. Outside air airflow
24. Outside air modulating damper position
25. Outside air minimum damper position
26. Outside air temperature
27. Outside air relative humidity
28. Exhaust air modulating damper position
29. Chilled water return valve command
30. Heating hot water return valve command
31. Final filter status
32. Mixed air temperature

3.2 VARIABLE VOLUME AIR HANDLING UNIT (AHU-3)

A. General: Air handling unit shall consist of supply and return fans, final filter, cooling and heating coils and economizer mixing box.

B. Indoor Design Temperature Criteria: 76 degree F (summer) and 68 degree F (winter).

C. Operational Schedule

1. Unit shall be energized through the energy management control system (EMCS) in the automatic mode based on the following adjustable schedule:

a.	Weekday:	7:00 a.m. to 5:59 p.m.	Occupied
b.		6:00 p.m. to 6:59 a.m.	Unoccupied
c.	Saturday:	7:00 a.m. to 5:59 p.m.	Occupied
d.		6:00 p.m. to 6:59 a.m.	Unoccupied
e.	Sunday:	12:00 a.m. to 11:59 a.m.	Unoccupied
f.	Holiday:	12:00 a.m. to 11:59 a.m.	Unoccupied

2. Provide capability for a time based override of 3 hours (adj.). The override time shall be variable between 1 and 4 hours. Upon receiving an override signal from a variable air volume thermostat, the air handling unit shall operate in override mode for the scheduled override time (3 hours, adj.).
3. After-hours Operation past Occupied hours
   a. Upon receiving an override signal from a zone controller, the EMCS shall energize the air handling unit associated with the after-hours zone and modulate all zones to minimum flow positions.
   b. The unit shall operate as during normal hours, including ventilation rates and economizer modes.
   c. Exhaust fans associated with the energized air handling unit shall remain off.
   d. The unit shall continue to operate in after-hours mode for the preset time set at the zone level controllers.
4. Unoccupied Hours Operation
   a. Upon receiving a signal from a zone controller that heat or cooling is required to maintain the zone setback heating or cooling temperature, the EMCS shall energize the air handling unit and modulate all zones to minimum flow positions.
   b. Exhaust fans associated with the air handling unit shall remain off and the outside air dampers shall remain closed.
   c. Cooling required during unoccupied mode:
      1) The supply air discharge temperature shall be set to 65°F (adj.)
      2) The economizer cycle shall be utilized when conditions permit as outlined in the economizer sequence of operations, otherwise the outside air dampers shall remain closed.
   d. Heating required during unoccupied mode:
      1) The supply air discharge temperature shall be set to 85°F (adj.)
      2) The outside air dampers shall remain closed.

D. Variable Frequency Drive Operating Modes

1. Hand Position: Fan shall run bypassing all control interlocks, all safety interlocks shall be satisfied (high static, fire alarm).
2. Off Position: Fans shall not run.
3. Auto Position: Fans shall run provided all safety provisions are satisfied.

E. Monitor

1. Supply Fan Status: The VFD shall report supply fan status via network card and current sensing relay to the EMCS.
2. Supply Fan Speed: The VFD shall report the supply fan speed to the EMCS.
3. Outside Airflow: The outside airflow measuring station shall report the outside airflow to the EMCS.
4. Supply Fan Airflow: The supply air airflow measuring station shall report the supply airflow to the EMCS.
5. Return Fan Status: The VFD shall report return fan status via network card and current sensing relay to the EMCS.
6. Return Fan Speed: The VFD shall report the return fan speed to the EMCS.
7. Return Fan Airflow: The return air airflow measuring station shall report the supply airflow to the EMCS.
8. Return Air Temperature: The return air temperature sensor shall report the return air temperature to the EMCS.
9. Mixed Air Temperature: The mixed air temperature sensor shall report the mixed air temperature to the EMCS.
10. Filter Status: The differential pressure sensor shall report the filter pressure drop to the EMCS.
11. All Valve Positions: Valve positions shall be reported via the control valve commanded position to the EMCS.
12. All Damper Positions: Damper positions shall be reported via the damper actuator commanded position to the EMCS.

F. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply Air Fan VFD Status OR VFD Alarm	Supply Air Fan Failure	Shut down supply air fan
One	Return Air Fan VFD Status OR VFD Alarm	Return Air Fan Failure	Shut down return fan
One	Supply Air discharge static pressure exceeds 3.5 inches W.C. (adj.)	Supply Air Fan High Static	Shut down AHU
One	Return Air discharge static pressure exceeds 2.5 inches W.C. (adj.)	Return Air Fan High Static	Shut down AHU
Two	High zone temperature	High Zone Temperature	None – notification only.
Two	Low zone temperature	Low Zone Temperature	None – notification only.
Two	High zone static pressure	High Zone Static Pressure	None – notification only.
Two	Low zone static pressure	Low Zone Static Pressure	None – notification only.
Two	Any valve command does not match status (alarm shall specify failed valve)	Valve Failure (showing name of alarmed valve)	None – notification only.
Two	Filter bank pressure differential exceeds 1-inch W.C.	Filter High Static	None – notification only.
Two	Any damper actuation failure (alarm shall specify failed damper)	Damper Failure (showing name of alarmed damper	None – notification only
Two	Outside airflow falls 10 percent below minimum for 5 minutes (adj.)	Low Ventilation Air	None – notification only

G. Fire Alarm Control
1. Activation of the duct detector in the fan discharge ductwork shall trigger a fire alarm. Fire alarm shall shutdown supply and return fans when the alarm is activated. The wiring and conduit from the duct detector for fan shut down shall be provided.
   a. Supply Fan: OFF as controlled by fire alarm.
   b. Return Fan: OFF as controlled by fire alarm.
   c. Outside Air (Minimum) Damper Position: CLOSED as controlled by fire alarm.
   d. Outside Air (Modulating) Damper Position: CLOSED as controlled by fire alarm.
   e. Return Air Damper Position: CLOSED as controlled by fire alarm.
   f. Exhaust Air Damper Position: OPEN as controlled by fire alarm.

H. Supply Air Temperature Control
1. The discharge air temperature shall signal the EMCS to modulate water flow to maintain discharge air temperature setpoint of 55°F (adj.)
2. The supply air temperature shall be reset from 55°F to 60°F (adj.) based on supply air temperature reset.
3. Supply air temperature reset
   a. During occupied mode, the supply air set point shall be reset from 55°F when outdoor temperature is 70°F (adj.) and above, proportionally up to 60°F (T-max) when outdoor air is 60°F and below.
   b. T-max shall be reset using trim and respond logic.
      1) While fan is proven on, increase setpoint by 0.2°F, every 5 minutes, if there are 3 (adj) or fewer zone cooling requests.
      2) If there are 3 (adj.) or more cooling requests decrease the setpoint by 0.2°F. A cooling request is generated when the cooling loop of any zone served by the system is greater than 99%.

c. Restrooms, corridors and storage space zones should be excluded from any reset schedule reference tables.

I. Supply Fan Static

1. Supply fan speed will modulate to maintain duct static pressure as described below
   a. The static pressure setpoint will be reset based on the highest zone pressure demand. The low/high static reset setpoints will be established by the test and balance contractor. The system will be programmed at startup with the following adjustable numbers;

Low Static Setpoint (LS-SP)	0.5 in WG
High Static Setpoint (HS-SP)	1.5 in WG

   b. Upon confirmed fan status, the supply fan VFD will be ramped up to meet the HS-SP. Once the setpoint is reached the VFD will be modulated to the meet the reset static pressure setpoint (RSP-SP).
   c. Duct Pressure Reset Schedule
      1) Static pressure setpoint shall be reset using trim and respond logic within the range shown above (to be confirmed by TAB contractor). When fan is off, setpoint shall be at minimum value.
      2) When fan is proven on, decrease set point by 0.05” WC every 2 minutes, if there are 2 (adj.) or fewer pressure requests. If there are more than 2 (adj.) pressure requests, increase the set point by 0.05” WC.
      3) The EMCS shall poll the position of each VAV terminal unit damper every 3 minutes (adj.).
      4) The position of each damper shall be reported by the VAV controller.
      5) Pressure request is generated when any VAV terminal unit served by the system is 85% open.
   d. Restrooms, corridors and storage space zones should be excluded from any reset schedule reference tables.
2. If at any time the duct static pressure measured at the high limit safety trip in the unit exceeds the duct static HS-SP, the inline mechanical high static safety switch will open and shut down all the associated fans. A high static alarm will be generated by way of an auxiliary set of contacts on the safety switch. The unit must be manually reset at the switch. The switch will be mounted in the control panel on exterior locations and adjacent to the control panel in indoor locations and where the control panel is mounted inside an access door on the AHU.

J. Outside Ventilation Air Control

1. Economizer Control
   a. Monitoring
      1) Reference outside air dry bulb temperature in °F.
      2) Common return air dry bulb temperature in °F.
   b. Operation
      1) The controller shall modulate the outside air modulating, exhaust air and return dampers in sequence to maintain the mixed air temperature setpoint 2°F (adj.) less than the discharge air temperature setpoint.
         (a) The economizer shall be enabled whenever:
            (i) Outside air temperature is less than 74°F (adj.).
            (ii) AND outside air dry bulb temperature is less than the common return air dry bulb temperature.
            (iii) AND the supply fan status is on.
            (iv) AND outside air relative humidity is less than 80% (adj.).
      2) When the unit is started in occupied mode and outside air temperature is less than 40°F (adj.), the modulating outside air damper shall ramp open to its minimum set point over a 5-minute (adj.) period and the economizer PID calculation shall be disabled. Only after this period shall the economizer PID output start calculating. When OAT is >40°F, there shall not be a delayed ramp open period.
      3) When economizer is enabled, the following operations shall be allowed to occur as needed and in the order listed to achieve mixed air temperature setpoint:
         (a) First, outside air minimum damper shall fully open.
         (b) Then, the outside air modulating damper shall modulate from closed to full open.

(c) Then, the return air damper shall modulate to fully closed. Economizer PID output shall continue to reset return damper from its controlled modulated position to achieve minimum OA and plenum pressures to fully closed, 0% open.
(d) Exhaust damper shall fully open.
4) The outside air modulating damper shall close and the return air damper shall open when:
(a) Mixed air temperature drops from 50°F (adj.) to 45°F (adj.).
(b) OR loss of supply fan on status.
(c) OR if unit is commanded off.

2. Demand Control Ventilation
a. Monitoring
1) Zone carbon dioxide levels in parts per million. Does not apply to all zones refer to plans for specific locations.
2) Outside ventilation airflow rate. (in cubic feet per minute).
3) Maximum allowable CO_2 levels: equal to outside air CO_2 concentration plus 600 ppm. This level shall be measured at 5 min. (adj.) intervals.
b. Operation
1) When not in economizer mode, unit shall operate at the demand control ventilation (DCV) minimum setpoint as indicated in the schedules with outside air minimum damper in open position.
2) If any zone air carbon dioxide levels reach the maximum allowable CO_2 levels, the modulating outside air damper shall begin to open.
3) The outside air modulating damper shall modulate from the DCV minimum setpoint to the maximum design outside air ventilation rate. The damper shall increase the outside air flow rate 10 percent (adj.) of the differential between maximum design outside air ventilation rate and DCV minimum setpoint every 1 minute (adj.).
4) If CO_2 level continues to be above maximum level the damper shall continue to open up to the maximum design outside air flowrate.
5) Once all zones are less than the maximum allowable CO_2 level the modulating outside air damper shall not open further. The damper shall remain at this flow rate until the CO_2 concentration in all zones drops below OSA concentration plus 500ppm (adj.).
6) Once the CO_2 concentration for all zones drops to outside air CO_2 concentration plus 400 ppm (adj.), the modulating outside air damper shall close.

K. Return Fan Control
1. The return fan speed shall be modulated to maintain an average zone pressurization of 0.01" w.c. (adj.) greater than the exterior reference pressure.
2. Variable speed drive shall be provided with a direct connection to the EMCS for monitoring and commanding the variable speed drive points from the EMCS workstation.

L. Morning Flush Control
1. Monitoring
a. Return air temperature
2. Operation
a. Prior to scheduled occupancy the air handling unit shall operate in 1 hour (adj.) flush mode followed by a warm up mode. In the flush mode the unit shall supply the minimum design outside ventilation air.
b. The supply air temperature setpoint shall be set to 55°F (adj.).

M. Morning Warm-Up
1. Morning warm-up shall run when the lowest indoor air temperature is less than 65°F (adj.).
2. The system shall be set to full recirculation and both outside air control dampers shall be closed. The chilled water valve shall be closed.
3. VAV boxes and reheat coil control valves shall remain fully open until the space temperature setpoint of 68°F (adj.) is achieved and then will modulate to maintain the space temperature setpoint.
4. System shall operate in this mode until internal temperatures setpoints are met at which point VAV boxes and air handling unit shall revert to normal operation.

N. Valve Failure Configuration

1. Actuation for the modulating outside air damper shall be fail closed.
2. Actuation for minimum outside air damper shall be fail open.
3. Actuation for return air modulating damper shall be fail open.
4. Actuation for exhaust air modulating damper shall be fail open.
5. Actuation for the chilled water control valve shall be fail open.
6. Actuation for the heating hot water control valve shall be fail open.

O. Refer to Zone Controls section for details of variable air volume box control.

P. Minimum Requirements for Operator Workstation Display

1. Supply fan VFD status
2. Supply fan VFD fault
3. Supply fan VFD by-pass
4. Supply fan on-off status
5. Supply fan speed
6. Supply fan static pressure setpoint
7. Supply fan static pressure (actual)
8. Supply fan high static pressure
9. Supply air airflow
10. Supply air temperature
11. Supply air temperature setpoint
12. Supply air downstream static pressure
13. Smoke Detector status
14. Return fan VFD status
15. Return fan VFD fault
16. Return fan VFD by-pass
17. Return fan on-off status
18. Return fan speed
19. Return fan high static pressure
20. Return air airflow
21. Return air temperature
22. Return air modulating damper position
23. Outside air airflow
24. Outside air modulating damper position
25. Outside air minimum damper position
26. Outside air temperature
27. Outside air relative humidity
28. Exhaust air modulating damper position
29. Chilled water return valve command
30. Heating hot water return valve command
31. Final filter status
32. Mixed air temperature

3.3 CONSTANT VOLUME PACKAGE UNIT (PAC-1)

A. General: Air handling unit shall consist of supply fan, final filter, DX coil and gas furnace.

B. Package unit shall be on emergency power.

C. Indoor Design Temperature Criteria: 66 degree F (summer) and 66 degree F (winter).

D. Operational Schedule

1. Unit shall be energized through the energy management control system (EMCS) in the automatic mode and will run 24/7 to maintain room air change requirements. DX coil or furnace will be activated to maintain the space temperature setpoint.

E. Monitor

1. Supply Fan Status: The supply fan status to be monitored via network card and current sensing relay to the EMCS.
2. Supply Fan Speed: Unit controller shall report the supply fan speed to the EMCS.
3. Supply Fan Airflow: The supply air airflow measuring station shall report the supply airflow to the EMCS.

4. Filter Status: The differential pressure sensor shall report the filter pressure drop to the EMCS.
5. Gas Valve Position: Valve position shall be reported via the control valve commanded position to the EMCS.
6. All Damper Positions: Damper positions shall be reported via the damper actuator commanded position to the EMCS.

F. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply Air Fan VFD Status OR VFD Alarm	Supply Air Fan Failure	Shut down supply air fan
One	Supply Air discharge static pressure exceeds 2.0 inches W.C. (adj.)	Supply Air Fan High Static	Shut down unit
Two	High zone temperature	High Zone Temperature	None – notification only.
Two	Low zone temperature	Low Zone Temperature	None – notification only.
Two	Gas valve command does not match status	Gas Valve Failure	None – notification only.
Two	Filter bank pressure differential exceeds 1-inch W.C.	Filter High Static	None – notification only.
Two	Any damper actuation failure (alarm shall specify failed damper)	Damper Failure (showing name of alarmed damper	None – notification only
Two	Outside airflow falls 10 percent below minimum for 5 minutes (adj.)	Low Ventilation Air	None – notification only

G. Fire Alarm Control

1. Activation of the area smoke detector in the space shall trigger a fire alarm. Fire alarm shall shutdown the supply fan when the alarm is activated. The wiring and conduit from the duct detector for fan shut down shall be provided.
   a. Supply Fan: OFF as controlled by fire alarm.

H. Valve Failure Configuration

1. Actuation for the modulating outside air damper shall be fail closed.
2. Actuation for minimum outside air damper shall be fail open.
3. Actuation for return air modulating damper shall be fail open.
4. Actuation for exhaust air modulating damper shall be fail open.
5. Actuation for the chilled water control valve shall be fail open.
6. Actuation for the heating hot water control valve shall be fail open.

I. Minimum Requirements for Operator Workstation Display

1. Supply fan on-off status
2. Supply fan speed
3. Supply fan static pressure setpoint
4. Supply fan static pressure (actual)
5. Supply fan high static pressure
6. Supply air airflow
7. Supply air temperature
8. Supply air temperature setpoint
9. Supply air downstream static pressure
10. Outside air temperature
11. Outside air relative humidity
12. Final filter status

3.4 LABORATORY EXHAUST FANS (EF-1, EF-2, EF-3, EF-4)

A. General

1. Unit shall run continuously and energized through the energy management control system (EMCS) in the automatic mode. The number of fans operating at any point in time will be staged to maintain the volume of air being exhausted from the building. The fans will modulate to maintain the suction static pressure determined by the Air Balancer.
2. Laboratory exhaust fan shall be on emergency power.
3. Prior to the initial start-up of the air handling units, the Laboratory Exhaust System shall be commanded to start to establish the "exhaust" flow control basis of the pressurization for the laboratory spaces.
4. The laboratory exhaust fans shall be start/stopped through the Energy Management Controls System (EMCS) based on the setting of the static pressure sensor mounted in the main exhaust air plenum on the roof level.
5. Upon system static pressure drop, the exhaust isolation dampers located on each fan inlet shall open and, when proven open, the exhaust fans shall start. Exhaust fans VFD will provide soft start only and will ramp fan speed up to the minimum VFD speed determined to be the frequency at which the nozzle outlet velocity is 3000 ft/min (adj.). The VFD speed will not drop below this value. Each following fan will start utilizing the same sequence. All fans running concurrently will run at the same speed.
6. The PID control will start to follow the system static pressure and static pressure set point. The system static pressure is maintained at the preset point of 3.5” WG (adj.). Based upon tracking position of general exhaust valves and fume hood exhaust valves, the required system static pressure set point can reset down to reduce energy consumption.
7. Each air bypass on the common fan plenum will modulate open based on the demand in air flow from the building so the fan design air flow will always be maintained constant.
8. As the need for exhaust air volume reduces, the bypass damper shall open to maintain exhaust static setpoint. When the bypass damper is 95% or more open for 3 minutes an exhaust fan will be commanded off. As the need for exhaust air volume increases the bypass damper will modulate close to maintain exhaust duct static setpoint. When the bypass damper is closed for 3 minutes an exhaust fan will be commanded on.
9. Exhaust fans shall be lead / lagged on a weekly basis. If a failure is sensed on a running fan, the lag fan will be energized. When the condition causing the failure is remedied and the unit’s alarm is reset, the original fan will energize and the lag fan will de-energize to resume normal operation.
10. On a failure of one (1) exhaust fan, the next fan in line will be commanded to start. The fan that failed shall be alarmed at the EMCS.
11. In a fire emergency, the fan VFD’s shall receive a hardwired signal from the fire alarm system to go to a field adjustable minimum speed for egress out of the laboratories. No control of this will be done via the EMCS. Exhaust fan system manifold will operate on continuous basis. General exhaust and fume hood exhaust valves will operate at minimum air flows.

3.5 NON-HOOD ROOM

A. As the static pressure in the exhaust and supply duct system fluctuates, the pressure independent cone/spring assembly of each Phoenix Venturi valve shall modulate to maintain a fixed setpoint flow within one second.

B. The Zone Balance Control function is responsible for summing the feedback of the supply and exhaust valves, factoring in the desired CFM offset value and commanding the valves under control to flow set points that satisfy the following equation: Supply = Exhaust – Offset (note: this is for a negatively pressurized room. For purposes of this sequence, we will assume a negatively pressurized room. Positively pressurized rooms operate similarly; the only difference is that you would add the offset instead of subtracting the offset). Beyond the desired ventilation rates and offset, thermal override and occupancy status may influence zone balance control to keep the space comfortable and in “balance.”

C. Temperature Control

1. A rise in temperature above the room set point flow causes the zone controller to send an increased signal to the supply valve to increase the airflow into the room. Zone pressurization is maintained by controlling the exhaust valve to a flow equal to the supply valve's feedback plus the design offset entering the space.
2. A drop in temperature below the room set point causes the supply and exhaust valves to decrease flow until their minimum positions are reached as listed on the air balance room schedules. On a further drop in zone temperature, the zone controller will drive open the heating hot water control valve serving the SAV reheat coil to maintain the temperature setpoint. Zone pressurization is maintained by controlling the exhaust valve to a flow equal to the supply valve's feedback plus the design offset entering the space.

D. EMCS Integration: Each room shall be integrated with the EMCS via PHX panel.

E. Occupancy Control: The airflow control system shall change the minimum ventilation and temperature control set points based on the occupied state to reduce energy consumption when the space is not occupied. Two occupancy modes shall be available: occupied and unoccupied. The room temperature sensor shall have a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The local occupancy override button shall be given priority over a command from the EMCS.

F. Emergency Mode Control

1. The airflow control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow setpoint. The system shall support up to four emergency control modes. The emergency control modes shall be initiated from the EMCS.
2. Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

G. Fail-Safe Condition for Loss of Power: The valves in this application have been configured to fail in their last position under the loss of power.

3.6 VAV-HOOD ROOM

A. Variable air volume (VAV) fume hoods are each designed to exhaust an amount of air that provides a constant face velocity (100 fpm) at the sash opening regardless of sash position. As each sash opening increases or decreases, the airflow exhausted through its associated hood exhaust valve changes proportionately, thereby maintaining a constant average face velocity at the sash opening.

B. An analog exhaust valve (FEV) with High-Speed Electric Actuation (HiSEA) is used to control the exhaust flow from each fume hood. Each hood exhaust valve is configured with a factory-mounted pressure switch to detect low static pressure across the valve. Each fume hood is equipped with:

1. A fume hood monitor, which generates an alarm to alert the operator to low static pressure and flow alarm conditions, and
2. A zone presence sensor, which sets back the face velocity when the fume hood is not occupied.

C. During initial commissioning, each fume hood monitor is calibrated to maintain the relationship between sash position and exhaust airflow so that a 100 fpm face velocity is obtained.

D. The variable supply airflow is controlled with an analog supply air valve (SAV). The minimum make-up airflow is sized to satisfy the minimum ventilation rate. The make-up air valve tracks the total fume hood exhaust flow minus the desired room offset until this minimum supply air flow is reached.

E. During conditions when the laboratory experiences a high internal heat gain (caused by season, time of day, people, lights, equipment, etc.), additional supply air is required to cool the space when all fume hood sashes are at their minimum openings. The EMCS sends a cooling demand, and the supply air valve opens in response to this demand for cooling, regardless of the hoods' total exhaust demand, thereby accomplishing temperature override control.

F. Neither the large minimum ventilation airflow nor the cooling override flow can all exhaust through the fume hoods when all the sashes are at their minimum openings. Therefore, a general exhaust valve (GEV) is added to the system to remove the zone's general exhaust air. The general exhaust valve operates inversely to the total hood exhaust flow when the total hood exhaust demand is less than either the supply air minimum ventilation airflow or the temperature override airflow.

G. This control approach works to maintain the minimum ventilation airflow, to accomplish temperature control of the laboratory, and to maintain overall zone pressurization control.

H. The EMCS controls the SAV reheat coil independently to provide laboratory temperature control.

I. Sequence of Operation
   1. Zone Pressurization Control
      a. As the static pressure in the exhaust and supply duct systems fluctuates, the pressure independent cone/spring assembly of each Phoenix Venturi valve shall modulate to maintain a fixed set point flow within one second.
      b. The Zone Balance Control function is responsible for summing the feedback of all the supply and exhaust valves, factoring in the desired offset value and commanding the valves under control to flow set points that satisfy the simplified equation: Total Supply = Total Exhaust – Offset. Beyond the desired ventilation rates and offset, Zone Balance Control may also be influenced by thermal override to keep the space comfortable and in "balance".
      c. The supply valve flow command shall be generated by comparing the minimum air change demand, the supply air for hood exhaust, and the thermal demand signals, and selecting the higher of these three settings.
      d. Negative zone pressurization is maintained by controlling the GEV. The general exhaust valve shall open when additional exhaust flow is required to maintain zone pressurization.
   2. Fume Hood Control
      a. As each fume hood's sash opening increases or decreases, the sash sensor signal to the related fume hood monitor shall change proportionally. (A sash sensor and monitor are mounted on each fume hood.)
      b. The fume hood monitor shall generate a 0-10 Vdc command signal. This 0-10 Vdc linear, calibrated command signal shall control its associated hood exhaust valve, thus maintaining a constant average face velocity at the fume hood opening. Each fume hood shall operate as a conventional variable air volume hood with a conventional face velocity (i.e., 100 fpm).
      c. Each hood exhaust valve shall generate a digital feedback signal, equal to the valve's airflow in CFM, and shall send this signal to the zone control module via the room-level network.
      d. When the differential static pressure across each hood exhaust valve drops below the valve's minimum operating differential static pressure, the differential pressure switch (mounted on each hood exhaust valve) shall open, causing its associated fume hood monitor to generate an audible and visual flow alarm, indicating that the valve is outside of its control range. Upon a valve jam condition (i.e., feedback signal does not equal command signal), the fume hood monitor shall also generate a flow alarm. A mute button shall silence the audible portion of the alarm. When system conditions return to normal, all alarms shall automatically clear.
      e. When there is no user at the fume hood, the zone presence sensor (ZPS) will send a signal to the fume hood monitor to set back the face velocity to 60 fpm (60 percent of its occupied level).
   3. Temperature Control
      a. The EMCS shall control the temperature of the space. A rise in temperature above the room set point causes the system to send a cooling demand signal to the supply valve to increase the airflow into the room. Negative zone pressurization is maintained by controlling the total exhaust valve to a flow equal to the supply valve's feedback plus the design offset entering the space Exhaust Flow = Supply Flow + (Offset). This is done by adjusting the command to the general exhaust valve.

b. A drop in temperature below the room set point causes the supply and general exhaust valves to decrease flow until their minimum positions are reached as listed on the room schedule sheet. On a further drop in zone temperature, the EMCS shall command the heating hot water control valve serving the reheat coil to open.

4. EMCS Integration: Each room shall be integrated with the EMCS via PHX panel.
5. Emergency Mode Control
   a. The airflow control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow setpoint. The system shall support up to four emergency control modes. The emergency control modes shall be initiated from the EMCS.
   b. Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

J. Fail-Safe Condition for Loss of Power: The valves in this application have been configured to fail in the following manner: Under loss of power, the supply and fume hood exhaust valves will fail to their maximum scheduled limit. The general exhaust valve will fail open or closed, whichever condition leaves the room with a pressure relationship closest to normal operation. These zones fail in a negative pressurization mode with an offset similar to normal operation.

3.7 CHILLED WATER SYSTEM

A. The chilled water supply to the new science building will be supplied from the campus central loop. The central plant of the campus provides 44°F supply and 60°F chilled water return with 16°F temperature differential. A flow meter will be added in the supply line to monitor and trend the total chilled water BTU.

3.8 HEATING HOT WATER SYSTEM

A. Primary Boiler Hot Water System
1. General
   a. The hot water system is designed to operate between 120-160 degrees F (adj.) supply water temperature.
2. Operating Schedule
   a. Upon receiving a signal that five or more zones, or air handling unit is calling for heating for 10 minutes (adj.), the start-up sequence shall be initiated. Initial start-up signal shall be generated when valve reaches 85% open.
   b. The primary boiler shall be B-1. Boilers lead-lag assignments shall be set weekly through the EMCS based on the boiler runtime.
   c. The primary unit shall have 15 percent (adj.) greater run time than all other equipment to prevent simultaneous failure or repair for equipment by providing unequal run time for the equipment.
3. Monitoring
   a. Boiler Status: Boiler status shall be monitored through a network control card included in the boiler controller.
   b. Boiler(s) run time: the EMCS shall track and store the run time for each boiler in hours and minutes.
4. Alarms: - An Alarm shall be reported to the EMCS workstation for the following conditions:

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Building loop's hot water return temperature falls below 90 degrees F (adj.) AND all boilers are energized	Low loop temperature	Notification only.
Two	Primary pump status in alarm AND no flow across boiler OR pump differential pressure transducer below 4 PSI (adj.) reading OR boiler start failure	Primary pump failure	Stage on next priority pump and boiler AND shut down alarmed pump AND shut down alarmed pumps associated boiler.
Two	Boiler Trouble Alarm	Boiler start fail/Boiler Trouble	Stage on next priority boiler AND shut down alarmed boiler AND shut down alarmed boilers associated pump.

5. Hot Water Supply Temperature Reset
    a. Initial heating hot water set point shall be 160 deg F.
    b. The EMCS shall poll the position of each modulating heating hot water control valve in the HHW system every 3 minutes (adj.).
    c. The position of each valve shall be determined based upon the 0–10 VDC or 4-20mA signal that has been sent to the control valve, with 0 VDC, 4mA being closed and 10 VDC or 20mA fully open.
    d. When the maximum polled valve position has dropped below 75 percent (adj.) for a period of 5 minutes (adj.), the EMCS shall reset the temperature setpoint downwards 2 degrees F (adj.), to a minimum 120 degrees F and maintain the maximum valve position at 80 percent (adj.)
    e. When the maximum polled valve position is above 85 percent (adj.) for a period of 5 minutes (adj.), the EMCS shall reset the temperature setpoint upwards 2 degrees F to a maximum of 160 degrees F (adj.), and maintain the maximum valve position at 80 percent (adj.)
    f. The reset control function priority shall be pressure then temperature. Temperature reset shall only be used once pressure set point is at minimum.
6. Start-up
    a. Upon receiving a signal for the EMCS to energize, the master boiler controller shall fully open the lead boiler's isolation valve. Master boiler controller to signal EMCS to energize the lead primary circulation pump.
    b. The master boiler controller shall notify the EMCS of any alarms, de-energize the lead boiler and energize the next priority boiler.
7. Staging
    a. Based upon the currently assigned priority order, the boiler systems master controller shall stage on boilers when the building loop hot water temperature falls 10 degrees F (adj.) below the setpoint for more than 10 minutes (adj.).
    b. The boiler's isolation valve shall be opened by the boiler master controller.
    c. After the isolation valve has opened as determined by an end switch on the valve, the Master boiler controller shall signal EMCS to energize the primary circulation pump.
    d. The boiler systems master controller shall control boiler staging to satisfy the system setpoint.
    e. EMCS shall monitor the amount of minutes that the lead boiler has been firing; second boiler shall not fire until lead boiler has been firing for 10 minutes (adj).

f. EMCS shall monitor and compare HHW supply temperature vs HHW supply setpoint. Subsequent boilers shall not operate if primary boiler can maintain setpoint.
g. Boiler restart time shall not be less than 30 minutes (adj.) or the manufacturer's minimum requirements whichever is greater.
h. Boiler Shutdown
    1) The master controller shall send the EMCS a signal whenever a boiler is staged off.
    2) The second and subsequent boilers shall be staged off when the HHW return water temperature rises to within 20 degrees F of supply setpoint.
    3) The EMCS shall signal the master boiler controller to close the isolation valve of the boiler that has been shut down after 5 minutes (adj. with a minimum setting of 5 minutes required).

8. Primary Pump Control: The primary pumps shall be controlled by the EMCS and shall be controlled as described in the start-up, staging and shut down sequences.
9. Shutdown
    a. When there are no zones or equipment receiving a signal for heating, the EMCS shall notify the Boiler master controller to de-energize all boilers.
        1) The boiler master controller shall report to the EMCS that all boilers have been de-energized.
    b. Upon receiving confirmation from the boiler master controller that all boilers have been de-energized, the EMCS shall de-energize the primary pump(s) after a run time of 5 minutes (adj. with a minimum setting of 5 minutes required).
    c. When pumps are de-energized, the EMCS shall signal the Boiler master controller to close the isolation valve for each boiler.
10. Minimum Requirements for Operator Workstation Display
    a. Heating hot water reset supply water temperature setpoint
    b. Boiler(s) On/Off status
    c. System modulation level
    d. Boiler(s) run time
    e. Heating hot water supply temperature setpoint
    f. Heating hot water supply temperature (per boiler)
    g. Heating hot water return temperature (per boiler)
    h. Boiler Isolation Valve(s) position.

B. Heating Hot Water System Variable Primary Control
1. General
    a. Each pump is furnished with a variable speed drive.
    b. Variable speed drives shall be provided with an EMCS network card for direct connection to the EMCS for monitoring and commanding variable speed drive points from the EMCS workstation.
2. Operating Schedule
    a. The heating hot water pumps HHWP-1 and HHWP-2 shall be energized by the EMCS upon a call for heating.
    b. The EMCS shall monitor the pump, schedule the pumps on and off to maintain the differential pressure set point.
    c. The primary pump shall be HHWP-1. Pumps lead-lag assignments shall be set weekly through the EMCS based pump run time.
    d. The primary unit shall have 15 percent (adj.) greater run time than all other equipment to prevent simultaneous failure or repair for equipment by providing unequal run time for the equipment.
3. Monitoring
    a. Pump(s) status: Monitored through a current sensor relay in the starter bucket.
    b. Pump(s) flow: The differential pressure transducer across the pump shall be monitored.
    c. Pump(s) VFD Status: Monitored through the VFD status.
    d. Pump(s) Speed: The VFD shall report the speed command to the EMCS.
    e. Pump run time: the EMCS shall track and store the run time for each pump in hours and minutes.
4. Alarms - An Alarm shall be reported to the EMCS workstation for the following conditions:

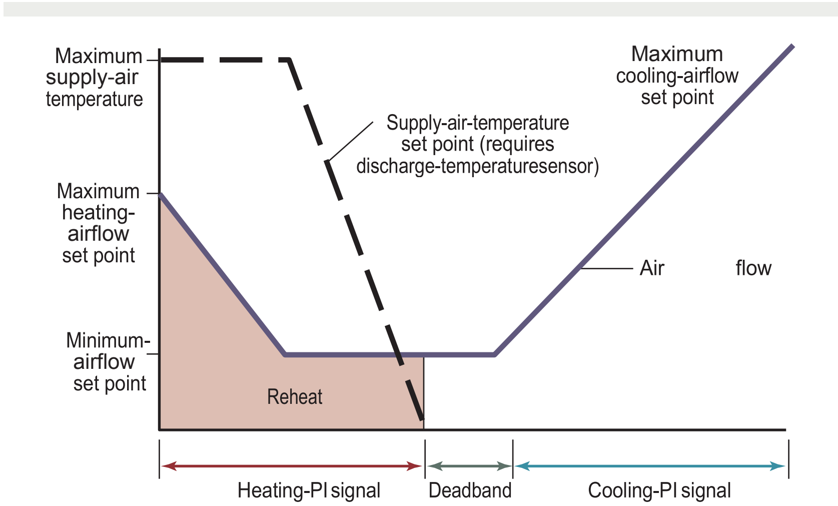
Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	VFD Status and/or Pump Differential Pressure less than 5 PSI (adj.)	Pump Failure	Shut down Alarmed Pump AND energize next priority pump.
One	Any VFD Fault	Display Fault Name received from VFD controller	Shut down Alarmed Pump AND energize next priority pump.
One	Flow meter reading less than the minimum flow rate through boiler. (minimum flow rate cumulative of the number of operating boilers)	Low water flow	Shut down pump and boiler

5. Speed Control
   a. Pressure Reset Schedule
      1) The EMCS shall poll the position of each modulating heating hot water control in the HHW system valve every 3 minutes (adj.).
      2) The position of each valve shall be determined based upon 0–10 VDC or 4-20mA signal that has been sent to the control valve, with 0 VDC, 4mA being closed and 10VDC or 20mA fully open.
      3) When the maximum polled valve position has dropped below 75 percent (adj.), the EMCS shall reset the differential pressure setpoint downwards 0.5 psi from 6 psi (adj.), and maintain the maximum valve position at 80 percent (adj.)
      4) When the maximum polled valve position is above 85 percent (adj.), the EMCS shall reset the differential pressure setpoint upwards 0.5 psi to a maximum of 6 psi (adj.), and maintain the maximum valve position at 80 percent (adj.)
   b. Staging Multiple Pumps
      1) When the speed of the lead pump reaches 85 percent (adj.) for 5 minutes, the next priority pump shall be energized slowly using PID ramp control as follows:
         (a) The EMCS shall monitor the speed signal of the lead pump and reduce the speed of the lead pump to 55 percent (adj.) of required operating speed as determined by the system curve.
         (b) The lag pump shall ramp up to meet the speed signal of the lead pump.
         (c) Both pumps shall be ramped up together until the differential pressure setpoint has been satisfied. Both pumps are controlled to the speed signal of the lead pump.
         (d) Both pumps will continue to run until both pumps are below 50 percent (adj.) for 5 minutes (adj.). The lag pumps shall ramp down slowly and let the lead pump ramp back up to meet the differential pressure setpoint.
6. Loop Monitoring
   a. Heating hot water supply and return water temperature shall be monitored by the EMCS.
   b. The EMCS shall monitor and record the heat hot water consumption from the energy meter located in the heating hot water loop.
   c. The EMCS shall monitor the flow rate in the primary loop.
7. Valve Actuation
   a. The EMCS shall schedule valve exercise for the heating hot water control valve once every three days during unoccupied hours and during occupied hours every third day prior to shut down of the primary pumps to allow circulation throughout the system.
      1) Each valve shall be sent a signal to fully open and close as part of the valve exercising.
   b. Actuation for the heating hot water control valves shall be fail open.
      1) Valves shall be actuated on central air handling units and boilers followed by zone valves.

8. Minimum Requirements for Operator Workstation Display
   a. Heating hot water supply temperature setpoint
   b. Heating hot water supply temperature
   c. Heating hot water return temperature
   d. Heating hot-water pump(s) on-off status.
   e. Heating hot-water pump(s) VFD speed.
   f. Heating hot-water differential pressure setpoint
   g. Heating hot-water differential pressure
   h. Heating hot-water primary flow rate
   i. Pump(s) run time.

3.9 ZONE CONTROLS

A. Variable Air Volume Terminal Units
   1. General: Room temperature sensor shall modulate the VAV airflow and HHW control valve to maintain room temperature setpoint: 76 ± 2 °F (cooling and 68 ± 2 °F (heating), (adj.) utilizing a dual maximum control strategy.
   2. Monitoring
      a. Space Temperature: The EMCS shall continuously monitor the space temperature from the zone thermostat.
      b. Space Airflow: The VAV controller shall continuously report the zone airflow.
      c. Damper Position: The VAV damper position shall be reported to the EMCS every 3 minutes (adj.).
   3. Airflow Control Damper: EMCS shall continuously monitor supply air flow via duct mounted air volume control unit and modulate the integral control damper to maintain space setpoint.
   4. Control
      a. When the zone is in the cooling mode, the cooling loop output is mapped to the airflow setpoint from the cooling maximum to the minimum airflow setpoints. The heating hot water valve is closed.
      b. When the zone is in the deadband mode, the airflow setpoint shall be the minimum airflow setpoint. The heating hot water valve is closed.
      c. When the zone is in the heating mode, the heating loop shall maintain space temperature at the heating setpoint as follows:
         1) From 0%-50% loop signal, the heating loop output shall reset the supply air temperature setpoint (e.g., 55°F) to 90°F and zone airflow at minimum airflow. Note the upper temperature is limited to prevent stratification during heating.
         2) From 50%-100% loop signal, the heating loop output shall reset the zone airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint. The supply air discharge temperature remains at 90°F.
      d. The hot water valve shall be modulated using a PI control loop to maintain the discharge temperature at setpoint. Note that directly controlling the hot water valve from the zone temperature PI loop is not acceptable since it will not allow supply air temperature to be under control and limited in temperature to prevent stratification.
      e. The VAV damper shall be modulated to maintain the measured airflow at setpoint.
   5. VAV Control Diagram



6. Demand Control Ventilation: If zone air carbon dioxide levels reach the maximum allowable CO_2 levels, associated zone terminal unit minimum position shall be reset to the maximum heating airflow setpoint. If the allowable CO_2 levels continue to not be met, the terminal unit shall continue to open at a rate of 10% per minute until the CO_2 concentration for all zones drops to outside air CO_2 concentration plus 500 ppm the zone terminal unit normal control.
7. Minimum Requirements for Operator Workstation Display
   a. Space setpoint temperature
   b. Space temperature
   c. VAV damper position
   d. VAV airflow
   e. Heating hot water valve position
8. Unoccupied Hours Setback Control
   a. If the space temperature rises above 85°F (adj.), the zone controller shall signal the EMCS that cooling is required. The EMCS shall initiate the associated AHU and operate until the space temperature reaches 78°F (adj.).
   b. If the space temperature drops below 60°F (adj.) and the outside air temperature is less than 55°F (adj.), the zone controller shall signal the EMCS that heating is required. The EMCS shall initiate the associated AHU and operate until the space temperature reaches 65°F (adj.).

B. Fan Powered Terminal Units (FPTU)

1. General
   a. The fan shall operate continuously during occupied hours to provide ventilation/make-up air and heating to the space.
2. Operational Schedule
   a. Unit shall be energized through the energy management control system (EMCS) in the automatic mode based on the following adjustable schedule:

1)	Weekday:	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
2)	Saturday:	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
3)	Sunday:	12:00 a.m. to 11:59 a.m.	Unoccupied
4)	Holiday:	12:00 a.m. to 11:59 a.m.	Unoccupied

3. Monitoring
   a. Space Temperature: the EMCS shall continuously monitor the space temperature from the zone thermostat
   b. Space airflow: the FPTU controller shall continuously report the zone airflow.
4. Reheat
   a. On a call for heating, the room temperature sensor shall modulate the hot water reheat valve to maintain the discharge air temperature setpoint of 82°F (adj.).
5. Zone Override

a. Each zone thermostat shall be provided with push button override. The push button override shall energize the respective air handling unit and provide operation for an override time period of 3 hrs (adj.).

6. Minimum Requirements for Operator Workstation Display:
   a. Space set point temperature
   b. Space temperature
   c. Supply air temperature set point
   d. Supply air temperature
   e. Associated AHU supply air temperature
   f. Primary actuator position
   g. Total Supply air airflow
   h. Reheat coil valve position
   i. Override status
   j. Fan Status

C. Fan Coil Unit (FCU-1-3, FCU-1-4)

1. Operation: Fan coil unit shall cycle with the space load to maintain the space temperature setpoint. The units shall operate on occupied hours.
2. Operational Schedule
   a. Unit shall be energized through the energy management control system (EMCS) in the automatic mode based on the following adjustable schedule:

1)	Weekday:	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
2)	Saturday:	7:00 a.m. to 5:59 p.m.	Occupied
		6:00 p.m. to 6:59 a.m.	Unoccupied
3)	Sunday:	12:00 a.m. to 11:59 a.m.	Unoccupied
4)	Holiday:	12:00 a.m. to 11:59 a.m.	Unoccupied

3. Monitor
   a. Supply Fan Status: A current sensor located in the starter bucket shall report the fan status.
   b. Discharge air temperature: Monitor discharge air temperature via temperature sensor.
   c. Condensation sensor: The EMCS shall continuously monitor the condensation sensor in the drain pan.
   d. Space Temperature: The EMCS shall continuously monitor the space temperature from the zone thermostat.
4. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply fan status failure	FCU failure	Shutdown alarmed FCU
One	Upon detection of moisture in the secondary drain pan by the moisture sensor mounted in the unit	Condensate drain failure	De-energize alarmed unit
Two	When the space temperature rises above 85°F (adj.)	High Temperature Alarm	Notification only.

5. Supply Fan: The supply fan shall be energized through the EMCS.
6. Supply Air Temperature Control
   a. Modulate chilled water control valve to maintain supply air setpoint.
   b. Setpoint Schedule (all adjustable)

Unit	Cooling
Electrical Rooms	80 degrees F

D. Variable Refrigerant Volume (VRV) System

1. Operation
   a. VRV System shall be energized through the energy management control system (EMCS) in the automatic mode and shall operate continuously.
   b. All VRV fan coil units shall cycle with the space load to maintain the space temperature set point. The fan coil units shall interface with associated heat pump condensing unit to provide cooling and can operate 24 hours a day.
   c. Operation control points
      1) System on/off command
      2) Operating mode
      3) Temperature set point
      4) Air flow rate (fan speed)
      5) Filter indicator reset
2. Monitor
   a. System on/off status
   b. Operation mode status
   c. Temperature setpoints
   d. Room temperature
   e. Airflow rate
   f. Filter indication status
   g. Error status
3. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply fan status failure	FCU failure	Shutdown alarmed FCU
One	Upon detection of moisture in the secondary drain pan by the moisture sensor mounted in the unit,	Condensate drain failure	De-energize alarmed unit
Two	When the space temperature rises above 80°F (adj.)	High Temperature Alarm	Notification only.

4. Supply Air Temperature Control
   a. Setpoint Schedule (all adjustable)

Unit	Cooling
BDF/IDF	75 degrees F
Elevator Machine Room	75 degrees F

3.10 FAN SYSTEMS

A. Exhaust Fans with Schedule Control (TEF-1)

1. Operational Schedule

a. Unit shall be energized through the energy management control system (EMCS) in the automatic mode and shall be interlocked with AHU-3.

2. Monitor

a. Exhaust Fan Status: Current sensing relay mounted in the fan starter bucket and report to EMCS.

3. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Exhaust Fan Status	Exhaust Fan Failure	Shut down alarmed fan.

B. Supply Fan with Schedule Control (SF-5)

1. Operational Schedule

a. Unit shall be energized through the energy management control system (EMCS) in the automatic mode and shall be interlocked with AHU-1.

2. Monitor

a. Supply Fan Status: Current sensing relay mounted in the fan starter bucket and report to EMCS.

3. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Supply Fan Status	Supply Fan Failure	Shut down alarmed fan.

C. Exhaust Fans with Schedule Control (EF-6)

1. Operational Schedule

a. Unit shall be energized through the energy management control system (EMCS) in the automatic mode and shall be interlocked with the laser cutter equipment.

2. Monitor

a. Exhaust Fan Status: Current sensing relay mounted in the fan starter bucket and report to EMCS.

3. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Exhaust Fan Status	Exhaust Fan Failure	Shut down alarmed fan.

3.11 MISCELLANEOUS SYSTEMS

A. Chimney Automation System (BEF-01, BEF-02)

1. Operation

a. EMCS shall monitor the chimney automation system status via a dry contact in the chimney automation system control panel (CONTROL).

b. Each boiler shall be interlocked with the CONTROL. Upon a call for heat, the CONTROL will activate the power venter to establish draft in the chimney system. Once draft setpoint is reached, the boiler proceeds to ignition. This sequence is repeated every time the boiler calls for heat without the CONTROL interrupting the sequencing of the boilers.

c. When a boiler shuts down, its gas valve is immediately closed. The power venter will slow down to satisfy the draft setpoint. Once the last boiler has shutdown, the power venter will continue to run in post purge mode for a set period of time to remove residual flue gases.
d. If proper draft cannot be maintained because of a mechanical or electrical failure, the CONTROL will go into alarm mode and the integrated proven draft function will shut down all boilers within 15 seconds and gas valves immediately closed. While in alarm mode, the control constantly monitors the draft. If the failure corrects itself or is corrected via intervention, the system will restart automatically.
e. If the power venter is out of commission for seven consecutive days, the bearing cycle activation function will allow the fan to operate at a low speed for a short time. This is automatically repeated every seven consecutive days the chimney fan does not operate.

2. Monitor:
   a. Chimney Automation System status for any alarm.

B. Plumbing Equipment

1. Monitoring: The EMCS shall monitor the following plumbing equipment:
   a. Domestic Hot Water Heater: On/Off operation monitored through runtime contacts on the domestic water pump.
   b. Domestic Hot Water Recirculation Pump: On/Off operation monitored through runtime contacts or relay on the domestic water pump.
   c. Domestic Water Booster Pump: On/Off operation monitored through contacts from pump control panel.
   d. Laboratory Air Compressor: On/Off operation monitored through contacts from pump control panel.
   e. Laboratory Vacuum Pump: On/Off operation monitored through contacts from pump control panel.
   f. Pure Water Equipment: On/Off operation monitored through contacts from pump control panel.
   g. pH Monitoring System: On/Off operation monitored through contacts from pH monitoring control panel.
2. Safeties and Alarms

Alarm Priority	Alarm Conditions	Alarm Reported	Action
One	Domestic Hot Water Heater alarm contact closes.	Domestic Hot Water heater failure	None – notification only.
One	Air Compressor alarm contact closes.	Air Compressor failure	None – notification only.
One	Domestic Hot Water Circulation Pump alarm contact closes.	Domestic Hot Water Pump failure	None – notification only.
One	Vacuum Pump alarm contact closes.	Vacuum Pump failure	None – notification only.
One	Domestic Water Booster Pump alarm contact closes.	Domestic Water Booster Pump failure	None – notification only.
One	Pure Water System alarm contact closes.	RO/DI equipment failure	None – notification only.
One	Greenhouse Pure Water System alarm contact closes.	Greenhouse DI equipment failure	None – notification only.
One	Emergency Generator alarm contact closes.	Emergency Generator equipment failure	None – notification only.

C. Metering Equipment

1. The EMCS shall monitor and track the following meters:
   a. Domestic Water meter.
   b. Greenhouse Domestic Water meter.
   c. Industrial Water meter.
   d. Natural Gas meter.
   e. Irrigation Water meter.
   f. Pure Water meter.
   g. Greenhouse pure water meter.
   h. Chilled Water meter.
   i. Heating Hot Water meter.
   j. Heating Hot Water system make-up water.

D. Sampling Box pH monitoring system

1. The EMCS shall monitor and track the quality of laboratory waste discharge.

END OF SECTION

SECTION 231123
FACILITY NATURAL GAS PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Valves.
   5. Pressure regulators.
   6. Mechanical sleeve seals.
   7. Grout.
   8. Concrete bases.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

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, crawlspaces, and tunnels.

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

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

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings
   1. Piping and Valves: 100 psig minimum unless otherwise indicated.
   2. Service Regulators: 65 psig minimum unless otherwise indicated.
   3. Minimum Operating Pressure of Service Meter: 0.5 psig.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   3. Pressure regulators. Indicate pressure ratings and capacities.
   4. Dielectric fittings.
   5. Mechanical sleeve seals.
   6. Escutcheons.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4-inch per foot.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of seismic restraints.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.

D. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

E. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

F. Qualification Data: For qualified professional engineer.

G. Welding certificates.

H. Field quality-control reports.

I. Operation and Maintenance Data: For pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

J. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.7 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated
   1. Notify Owner no fewer than 5 days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without the Owner's written permission.

1.8 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 – ACCESS DOORS AND FRAMES.

PART 2 PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53 / A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings
      a. Material Group: 1.1.
      b. End Connections: Threaded or butt welding to match pipe.
      c. Lapped Face: Not permitted underground.
      d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
      e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
   5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
      a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
   6. Mechanical Couplings
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Dresser Piping Specialties; Division of Dresser, Inc.
         2) Smith-Blair, Inc.
      b. Steel flanges and tube with epoxy finish.
      c. Buna-nitrile seals.
      d. Steel bolts, washers, and nuts.
      e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
      f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors
   1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
   2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
   3. Operating-Pressure Rating: 0.5 psig.
   4. End Fittings: Zinc-coated steel.
   5. Threaded Ends: Comply with ASME B1.20.1.
   6. Maximum Length: 72 inches.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
   1. Copper-alloy convenience outlet and matching plug connector.
   2. Nitrile seals.
   3. Hand operated with automatic shutoff when disconnected.
   4. For indoor or outdoor applications.
   5. percent free area.
   6. CWP Rating: 125 psig.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. BrassCraft Manufacturing Company; a Masco company
      b. ConBraCo Industries, Inc.; Apollo Div.
      c. McDonald, A. Y. Mfg. Co.
      d. Perfection Corporation; a subsidiary of American Meter Company.
      e. Or equal.
   2. Body: Bronze, complying with ASTM B 584.
   3. Ball: Chrome-plated brass.
   4. Stem: Bronze; blowout proof.
   5. Seats: Reinforced TFE; blowout proof.
   6. Packing: Separate packnut with adjustable-stem packing threaded ends.
   7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   8. CWP Rating: 600 psig.
   9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Lee Brass Company.
      b. McDonald, A. Y. Mfg. Co.
      c. Or equal.
   2. Body: Bronze, complying with ASTM B 584.
   3. Plug: Bronze.
   4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   5. Operator: Square head or lug type with tamperproof feature where indicated.
   6. Pressure Class: 125 psig.
   7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Non-lubricated Plug Valves: MSS SP-78.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. McDonald, A. Y. Mfg. Co.
      b. Mueller Co.; Gas Products Div.
      c. Xomox Corporation; a Crane company.
      d. Or eqaul.
   2. Body: Cast iron, complying with ASTM A 126, Class B.
   3. Plug: Bronze or nickel-plated cast iron.
   4. Seat: Coated with thermoplastic.
   5. Stem Seal: Compatible with natural gas.
   6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   7. Operator: Square head or lug type with tamperproof feature where indicated.
   8. Pressure Class: 125 psig.
   9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
      a. Pacific Seismic Products, Inc.
      b. Or equal.
   2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   3. Maximum Operating Pressure: 7 psig.
   4. Cast-aluminum body with stainless-steel internal parts.
   5. Nitrile-rubber, reset-stem o-ring seal.
   6. Valve position, open or closed, indicator.
   7. Composition valve seat with clapper held by spring or magnet locking mechanism.
   8. Level indicator.
   9. End Connections: Threaded for valves NPS 2 and smaller; flanged for valves NPS 2-1/2 and larger.

2.6 PRESSURE REGULATORS

A. General Requirements
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton Corporation; Controls Div.
      b. Maxitrol Company.
      c. Or equal.
   2. Body and Diaphragm Case: Die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
      a. Diaphragm Plate: Zinc-plated steel.
      b. Seat Disc: Nitrile rubber.
      c. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
      d. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
      e. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
      f. Maximum Inlet Pressure: 1 psig.

2.7 DIELECTRIC FITTINGS

A. General: Refer to Section 220500 – Common Work Results for Plumbing.

2.8 SLEEVES

A. General: Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

2.9 MECHANICAL SLEEVE SEALS

A. General: Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

2.10 ESCUTCHEONS

A. General: Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

2.11 GROUT

A. General: Refer to Section 220500 – COMMON WORK RESULTS FOR PLUMBING.

2.12 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

B. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 – EARTH MOVING FOR EXCAVATING, TRENCHING, AND BACKFILLING.

  1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Steel Piping with Protective Coating

  1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
  2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
  D. Replace pipe having damaged PE coating with new pipe.

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

F. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

  1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

G. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

H. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

I. Install pressure gauge upstream and downstream from each service regulator. Pressure gages are specified in Section 220519 – METERS AND GAGES FOR HVAC PIPING.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

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

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

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

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

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

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Install escutcheons at penetrations of interior walls, ceilings, and floors. Refer to Section 230518 – ESCUTCHEONS FOR HVAC PIPING.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 078413 – PENETRATION FIRESTOPPING.

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps
   1. Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   2. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
   1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
   2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
   3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
   4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
      a. Exception: Tubing passing through partitions or walls does not require striker barriers.
   5. Prohibited Locations
      a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
      b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

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

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

C. Threaded Joints
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints
   1. Construct joints according to AWS D10.12 / D10.12M, using qualified processes and welding operators.
   2. Bevel plain ends of steel pipe.
   3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

B. Comply with requirements for pipe hangers and supports specified Section 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT, for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.
   a. Prime Coat: Alkyd anticorrosive metal primer.
   b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
   c. Topcoat: Exterior alkyd enamel (flat).
   d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   a. Prime Coat: Alkyd anticorrosive metal primer.
   b. Intermediate Coat: Interior latex matching topcoat.

c. Topcoat: Interior latex (flat).
d. Color: Gray.
2. Alkyd System: MPI INT 5.1E.
a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior alkyd matching topcoat.
c. Topcoat: Interior alkyd (flat).
d. Color: Gray.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 CONCRETE BASES

A. General: Refer to Section 230500 – COMMON WORK RESULTS FOR HVAC.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections

C. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

D. Natural gas piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 DEMONSTRATION

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

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:
1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, NPS 2 and smaller piping shall be the following:

B. Steel pipe with malleable-iron fittings and threaded joints.

C. Aboveground, NPS 2-1/2 and larger piping shall be the following:

D. Steel pipe with wrought-steel fittings and welded joints.

E. Underground, below building, piping shall be the following:

F. Steel pipe with wrought-steel fittings and welded joints.

G. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

H. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
1. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be the following:
1. Cast-iron, non-lubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be the following:
   1. Bronze plug valve.
D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be the following:
   1. Cast-iron, non-lubricated plug valve.
E. Valves in branch piping for single appliance shall be the following:
   1. Bronze plug valve.

END OF SECTION

SECTION 232113
HYDRONIC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Heating hot water piping.
   2. Chilled water piping.
   3. Air vent piping.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

C. Related Sections include the following:
   1. Section 232113 – Hydronic Pumps for pumps, motors, and accessories for hydronic piping.

1.2 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature
   1. Hot-Water Heating Piping: 150 psig at 200 degrees F.
   2. Chilled-Water Piping: 150 psig at 150 degrees F.
   3. Air-Vent Piping: 200 degrees F.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

B. Pipe shall be stored on dunnage and plugged to prevent intrusion of foreign matter.

1.5 SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe materials, pipe fittings and joints.
   2. Pressure-seal fittings.
   3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   4. Air control devices.
   5. Hydronic specialties.

B. LEED Submittal
   1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Shop Drawings: Detail, at 1/4-scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops. Indicate all valves and items of equipment.

D. Valve schedule listing each valve number, valve type, size, model and service. Cross reference to supporting product data.

E. Welding certificates, certificates must be current dated within 6 months of work being performed and maintained current through duration of work.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

H. Anchorage and support details on each hydronic specialty. All anchorage calculations shall be prepared by a Structural Engineer registered with a valid California license.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Qualifications shall be for both acetylene and arc welding of ASA Schedule 40 ASA A53, Type B or ASA Type B or ASA A120 Type B carbon steel welded pipe in the "Horizontal Position" (2G) and the "Horizontal Fixed Position" (5G) as defined by said code.
3. Certificate described above is not valid unless it has been issued while welder was working for his current employer, and unless welder has performed type of work described by certificate in preceding 3 months.
4. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Each successful welder will carry an identification card listing his name, date of test, and type of welding tests passed; signed by the welder and the laboratory.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

E. Qualification Tests

1. Tests shall be made on 3-inch standard weight pipe ASTM A53, Grade A, and shall be welded by acetylene and electric arc. Each sample shall consist of 2 pieces, each 10 inches long, with 30-degree bevel at point weld.
2. Two 20-inch samples shall be made in the "2G" and two 20-inch samples in the "5G" positions. (Positions are as defined in Section IX, ASME Code.) These welds shall have the reinforcement ground or machined flush to the surface of the pipe before testing. Samples shall be tested as full section tensile.
3. Weld shall develop a load of 90% of 50,000 psi, i.e., 45,000 psi or shall develop a fracture in parent metal.

F. The Owner’s Representative reserves the right to test the work of any welder employed on the project, at the Owner's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project and all defective welds replaced.

G. The Owner may, at the Owner’s expense, initially x-ray inspect welds in accordance with ANSI B31.9. Welds not in conformance will be replaced by the contractor at his expense. Costs of x-raying the new weld will be borne by the contractor.

1.7 EXTRA MATERIALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type K and L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53 / A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234 / A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Anvil International, Inc.
   b. Victaulic Company of America
   c. Or equal
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47 / A 47M, Grade 32510 malleable iron; ASTM A 53 / A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Steel Pipe Nipples: ASTM A 733, 3-inch long, schedule 80 seamless black steel. Use of close nipples with less than 1-inch of unthreaded pipe is prohibited.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12 / D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Charlotte Pipe and Foundry Company.
      b. IPEX Inc.
      c. KBi.
      d. Or equal.
   2. CPVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Charlotte Pipe and Foundry Company.
      b. IPEX Inc.
      c. KBi.
      d. NIBCO, Inc.
      e. Or equal.
   2. MSS SP-107, CPVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.5 DIELECTRIC FITTINGS

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

B. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

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

D. For connection of ferrous piping to copper piping, dielectric joints shall be constructed of schedule 40 red brass nipples, minimum length six (6) times pipe diameter (6” min); 2- inch and smaller with threaded ends; 2-1/2 inches and larger with flanged connections.

2.6 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 – GENERAL DUTY VALVES FOR HVAC PIPING.

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230923 – INSTURMENTATION AND CONTROL DEVICES FOR HVAC.

C. Bronze, Calibrated-Orifice, Balancing Valves
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Bell & Gossett Domestic Pump; a division of ITT Industries.
      b. Griswold Controls.
      c. Taco.
      d. Or equal.

2. Body: Bronze, ball or plug type with calibrated orifice or Venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 150 psig.
10. Maximum Operating Temperature: 250 degrees F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Bell & Gossett Domestic Pump; a division of ITT Industries.
   b. Griswold Controls.
   c. Taco.
   d. Tour & Andersson; available through Victaulic Company of America.
   e. Or equal.
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venture with integral pointer and calibrated scale to register degree of valve opening.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals and check valves for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 150 psig.
11. Maximum Operating Temperature: 250 degrees F.

E. Diaphragm-operated, Pressure-Reducing Valves

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Amtrol, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   d. Or equal.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Monel, removable without system shutdown.
9. Valve seat and stem: Non-corrosive.
10. Valve size, capacity and operating pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-operated, Safety Valves

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Amtrol, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   d. Or equal.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.

6. Diaphragm: EPT.
7. Wetted , Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Monel, removable without system shutdown.
9. Valve seat and stem: Non-corrosive.
10. Valve size, capacity and operating pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.7 DRAIN VALVES

A. Use 3/4-inch ball valve with threaded hose adapter except strainer blowdown valves to be the same size as the blowdown connection.

2.8 AIR CONTROL DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Bell & Gossett Domestic Pump; a division of ITT Industries.
   2. Amtrol, Inc.
   3. Wessels.
   4. Taco.
   5. Or equal.

B. Manual Air Vents
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Screwdriver or thumbscrew.
   4. Inlet Connection: NPS 1/2.
   5. Discharge Connection: NPS 1/8.
   6. CWP Rating: 150 psig.
   7. Maximum Operating Temperature: 225 degrees F.

C. Automatic Air Vents
   1. Body: Bronze or cast iron.
   2. Internal Parts: Nonferrous.
   3. Operator: Noncorrosive metal float.
   4. Inlet Connection: NPS 1/2.
   5. Discharge Connection: NPS 1/4.
   6. CWP Rating: 150 psig.
   7. Maximum Operating Temperature: 240 degrees F.

D. Bladder-Type Expansion Tanks
   1. Tank: Welded steel, rated for 150 psig working pressure and 375 degrees F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   2. Bladder: Butyl-rubber securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
   3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
   4. Gauge Glass.
   5. Tank Drain Fitting: Brass body, non-ferrous internal parts; 150 psig working pressure and 240 degrees F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

E. Tangential-Type Air Separators
   1. Tank: Welded steel, ASME Constructed and rated for 150 psig working pressure and 375 degrees F maximum operating temperature.
   2. Air collector tube: Perforated stainless steel, constructed to direct released air into expansion tank.
   3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
   4. Blowdown connection: Threaded.

5. Size: Match system flow capacity.

2.9 HYDRONIC PIPING SPECIALTIES

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the Drawings or comparable product by one of the following:
   1. Bell & Gossett Domestic Pump; a division of ITT Industries.
   2. Mueller.
   3. Keckley.
   4. Taco.
   5. Or equal.

B. Y-Pattern Strainers
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 20-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 150 psig.

C. Basket Strainers
   1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 20-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 150 psig.

D. Suction Diffuser
   1. Furnish and install as shown on plans, an angle pattern flow straightening fitting equipped with a combination diffuser strainer- orifice cylinder, flow straightening vanes, start-up strainer and adjustable support foot.
   2. The combination diffuser-strainer-orifice cylinder shall be designed to withstand pressure differential equal to the system pump shutoff head and shall have a free area equal to five times the cross section area of the pump suction opening. The length of the flow straightening vanes shall be no less than 2-1/2 times the diameter of the system pump suction connection.
   3. Cast Iron Flanged Models Rated for a Maximum Working Pressure of 150 psig. The flow straightening fitting shall be of cast iron construction with flanged system and flanged pump connections. The fitting shall be have a Stainless steel combination diffuser-strainer-orifice cylinder with 3/16-inch diameter perforations to protect the system pump. The full length Carbon steel flow straightening vanes shall provide non-turbulent flow to the suction side of the system pump. The start-up strainer shall be of 16-mesh bronze, and the support foot shall eliminate pipe strain at the flow fitting/pump connection. All internal components shall be replaceable.
   4. Adjustable foot support shall be supplied by the contractor and not form an integral part of the suction diffuser.

E. Stainless-Steel Bellow, Flexible Connectors
   1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
   2. End Connections: Threaded or flanged to match equipment connected.
   3. Performance: Capable of 3/4-inch misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 degrees F.

F. Spherical, Rubber, Flexible Connectors
   1. Body: Fiber-reinforced rubber body.
   2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   3. Performance: Capable of misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 degrees F.

G. Expansion fittings are specified in Section 230516 – EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS

A. Heating hot water piping, aboveground, NPS 2 and smaller, shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

B. Heating hot water piping, aboveground, NPS 2-1/2 and larger shall be:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

D. Chilled-water piping, concealed, aboveground, NPS 2-1/2 and larger, shall be:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Chilled-water piping, exposed within mechanical room, NPS 3 and larger, shall be any of the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
   2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
      a. Exception: Not permitted on coil connection branches.

F. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

G. Air-Vent Piping
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
   2. Outlet: Type L, annealed-temper copper tubing with brazed or flared joints.

3.2 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install throttling-duty valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install spring loaded check valves at each pump discharge and elsewhere as required to control flow direction.

E. Discharge piping from water relief valves shall be extended to drain with adequate capacity for full relief flow. Run each relief valve separately.

F. Minimum relief valve capacity shall be such that the relief valve or valves will discharge the full capacity of the largest regulating valve without allowing the lower pressure to rise more than 6 percent above the highest pressure at which any valve is set. No relief valve will be required where a further reduction in pressure is made, unless reducing valve failure would result in equipment damage, in such cases, the same rule will apply for the lower pressure.

G. Install valves with stems upright or horizontal, not inverted. No valve will be permitted with stem below horizontal.

H. All exposed valves located more than 8 feet 0 inches above the floor shall be equipped with chains and chain operators extending to within 6 feet 0 inches of the floor.

I. Valves 6 inches and larger shall be gear operated.

J. Unless identified on the Drawings, each valve shall be the same size as the pipe in which it is installed.

K. Use lug type butterfly valves in for isolation of equipment on sizes 3 inches and larger.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Mechanical grooved fittings shall be used on chilled water only and only in exposed interior and exterior locations.

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

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

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

F. Where connecting a series of valves use nipples in copper piping use heavy brass nipples.

G. Install piping to permit valve servicing.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Group piping whenever practical at common elevations.

L. Select system components with pressure rating equal to or greater than system operating pressure.

M. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

N. Install drain valves at all low point pockets on piping system where volume of water trapped is 3 gallons or greater.

O. Install air vents at all high points of the system.

P. Install piping at a uniform grade of 0.2 percent upward from main riser locations to facilitate full drainage of the system.

Q. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

R. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

S. Install valves according to Section 230523 – GENERAL DUTY VALVES FOR HVAC PIPING.

T. Install unions in piping, NPS 2 and smaller, adjacent to valves, controls, regulators, at final connections of equipment, and elsewhere as indicated, including condensate drains.

U. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated, including condensate drains.

V. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

W. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 230516 – EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING.

X. Identify piping as specified in Section 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.

Y. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 083113 – ACCESS DOORS AND FRAMES.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT. Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

C. Install the following pipe attachments

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 100 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 100 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes

1. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8-inch.
2. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2-inch.
3. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2-inch.
4. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8-inch.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4-inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4-inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

G. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

H. Line valves shall be supported at the valve in addition to the regularly spaced pipe supports.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12 / D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Strainers shall be placed ahead of all pumps, regulators, automatic valves and where shown on the drawings.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms. Automatic air vents shall be piped to drain.

C. Install manual air vents in all other locations at high points in piping, at heat-transfer coils, and at all air pockets created by pipe routing.

D. Install tangential air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.

E. Install expansion tank on the floor. Vent and purge air from hydronic system and ensure tank is properly charged with air to suit system Project requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Section 230519 – METERS AND GAGES FOR HVAC PIPING.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows

B. Leave joints, including welds, uninsulated and exposed for examination during test.

1. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

C. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.

3. Subject piping system to hydrostatic test pressure of 200 psig for 4 hours. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

D. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type). Set temperature controls so all coils are calling for full flow.
5. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 232114
UNDERGROUND HYDRONIC PIPING

PART 1 GENERAL

1.1 WORK INCLUDED

A. Contractor to design anchors, guides, hangers and expansion compensation system based on coordinated piping layout as submitted in shop drawings. Anchor and expansion compensation location as shown on bid documents are suggested only.

B. Drawings, Specifications, General Contract Conditions etc. relate to the Campus Utility work shall apply to this section.

1.2 SUMMARY

A. This Section includes providing a complete piping system for underground chilled water pipes from the campus loop point of connection to the building. This applies to direct buried piping and piping installed in trenches.

B. Refer to 232113 HYDRONIC PIPING for hydronic piping and accessories.

C. The design drawings are diagrammatic and intended to show the proposed routing and scope of the work. The contractor shall design build and field coordinate the chilled water installation, provide all necessary piping, fittings, offsets, pipe anchors, supports, alignment guides, expansion joints and loops, thrust blocks, manholes etc. required for a complete installation. Refer to civil section for concrete manhole requirements.

D. Coordinate with all site work under this contract. Coordinate all points of entry into the building with structure, MEP services, civil and architecture.

E. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.3 RELATED WORK

A. Other Division Sections relating to trenching, backfilling, asphalt and concrete paving etc.

B. Section 230700 – MECHANICAL INSULATION

C. Section 230800 – MECHANICAL SYSTEMS COMMISSIOINING

D. Section 232113 – HYDRONIC PIPING

1.4 PERFORMANCE REQUIREMENTS

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

   1. Chilled Water Piping: 150 psig at 150°F

1.5 DELIVERY, STORAGE, AND HANDLING

A. Pipe shall be stored on dunnage and plugged to prevent intrusion of foreign matter.

B. All requirements as described in Section 232113 HYDRONIC PIPING.

1.6 SUBMITTALS

A. Product data: Complete material list of all items proposed to be furnished and installed under this section.

B. Manufacturer’s specifications and other data required to demonstrate compliance with the specified requirements.

C. Manufacturer's recommended installation instruction and installation procedures.

D. Shop drawings show:
   1. Complete system layout and description of components for all piping including all expansion loops, elbows, anchor points, fittings, and other necessary thrust block etc.
   2. Schedule and description of pipe and fittings.
   3. Schedule of pipe anchors and thrust blocks.
   4. Specialty fittings.

E. Welding certificates.

F. Material test reports.

G. Source quality control report.

H. Field quality control report.

I. Qualification of manufacturer and installer per description below.

J. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.7 QUALITY ASSURANCE

A. Refer section 232113 HYDRONIC PIPING for additional requirements.

B. Qualifications of Manufacturer: Products used in the Work of this Section shall be produced by manufacturers regularly engaged in manufacture of similar items and with a history of successful production acceptable to the Owner's Representative.

C. Qualifications of Installers: Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

PART 2 PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53 / A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

2.2 PIPING SPECIALTIES

A. Sleeves: Sleeves for wall penetrations shall be fabricated of 1/8 inch thick steel, with 2 inch wide collar welded in place, and the assembly hot-dip galvanized.

B. Wall Penetration Seals: High temperature Elastomeric link type mechanical seals compressed with corrosion-protected bolts and compression plate; Thunderline Link-Seal, or equal.

2.3 CASED PIPING SYSTEM

A. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

B. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Perma-Pipe, Inc.

2. Rovanco Piping Systems, Inc.
3. Thermacor
4. Thermal Pipe Systems.
5. Or equal.

C. Chilled-Water, Hot-Water Heating Carrier Pipe:
   1. NPS 2-1/2 and larger shall be: A-53 grade B ERW Schedule 40 steel pipe, wrought-steel fittings and butt welded joints.

D. Carrier Pipe Insulation:
   1. Polyurethane Foam Pipe Insulation: Rigid, cellular, high-pressure injected between carrier pipe and jacket. Comply with the following:
      a. 90% minimum closed cell polyurethane with a minimum 2.0 lbs per cubic foot density, a compressive strength of 30 psi at 75 degrees F.
      b. Comply with ASTM C 591; thermal conductivity (k-value) shall not exceed 0.18 Btu x in./h x sq. ft. x degrees F at 75 degrees F after 180 days of aging.

E. Casing shall be the following:
   1. PVC or HDPE

F. Casing accessories include the following:
   1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
   2. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

G. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 EXECUTION

3.1 TRENCHING, BACKFILLING, AND COMPACTING

A. Refer also to Sections relate to Earthwork and Section relate to Excavation Support and Protection.

B. Trenching: Owner may limit the amount of trench to be opened at any time.

C. Backfilling: Backfilling of trenches shall progress as rapidly as construction, testing, and acceptance of work permits.

D. Damage Repair: Utilities, walls, piping, and other improvements damaged during the course of work shall be repaired to their original condition or replaced at no increase in Contract Sum.

E. Excess Material: Excess material and debris shall be removed and disposed to an approved disposal site.

3.2 PIPING APPLICATION

A. Chilled Water Piping
   1. Cased piping with polyurethane carrier pipe insulation:
      a. Piping Material, Insulation and Jacket Thickness:

Nominal Pipe Size in inches	Minimum Insulation Thickness in inches	Jacket Size in Inches	Jacket Thickness in Mils
6	1.68	10	100
8	1.68	12	120

3.3 PIPING INSTALLATION

A. General

1. Piping and pipe systems shall be fabricated, assembled, welded, and installed in accordance with ANSI B31.1 and ANSI B2.2.
2. Piping shall be cut accurately to field measurements and worked into place without springing or forcing, except where cold-springing is specified. Piping shall not be buried, concealed, or insulated until it has been inspected, tested, and approved.
3. Materials and equipment shall be protected from dirt and the weather during construction.
4. Arrangement of all piping shall be shown on the drawings. During installation, care shall be taken to avoid interference with other piping, conduit, and equipment.
5. Reducing fittings shall be used for changes in pipe sizes. Bushings shall not be used.
6. In horizontal lines 2 inch and larger, reducing fittings of the concentric type shall be used.
7. Pipe shall be adequately supported and anchored so that strain from weight and thermal movement of piping is not imposed on equipment.
8. Each length of cased pipe shall be protected from damage in shipment with acceptable methods of blocking and crating. Handling and unloading shall be done in a manner to protect the outer jacket from damage of any kind.

B. Cleaning: See Section 232113 HYDRONIC PIPING.

C. Pipe Expansion: Expansion of pipes shall be accommodated by expansion loops Z-bends or L-Bends in buried locations, or expansion joints in manholes, tunnels and buildings. Cold-springing of piping shall be executed during field assembly in accordance with the calculated maximum operational expansion as indicated on the drawings. Expansion joints shall be set to ensure proper function and movement during system operation.

D. Pipe shall be wrapped in 2 inch minimum thickness fiberglass blanket at all expansion loops and bends to accommodate thermal movements. See drawings for additional fiberglass blanket requirements.

E. Connections: Locations of capped or plugged outlets for future connections shall be shown on the drawings. Weldolets or flanged fittings shall be used for tapping existing systems.

F. Welding: See 232113 HYDRONIC PIPING for welding requirements.

G. Anchor Blocks: Concrete anchor blocks shall be provided for pipe anchorage not less than 5 feet from building or manhole walls (except where metal harness is specified or shown on the Drawings). Anchor blocks shall be cast against undisturbed earth using concrete that conforms to ASTM C94 and has a minimum compressive strength of 2,500 psi at 28 days.

H. Wall Penetrations: Galvanized steel sleeves shall be provided for penetrations in concrete wall 6 inch or less in thickness, and masonry walls. Existing concrete walls thicker than 6 inch shall be core drilled or equipped with galvanized steel sleeves. High temperature elastomeric link type seals shall be acceptable for use in all locations.

3.4 JOINT CONSTRUCTION

A. See Section 230500 – COMMON WORK RESULTS FOR HVAC for basic piping joint construction.

B. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

F. Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.5 CASED PIPING SYSTEM

A. Piping system shall be provided with all straight pipe and fittings factory preinsulated and prefabricated to job dimensions. Piping systems shall be provided with a factory insulated straight pipe section and factory prefabricated fittings, or at the Owner’s and Owner’s Representative’s option, field fabricated fittings insulated with kits provided by the system manufacturer.

B. Install piping with top of pipe 36” min. below finished grade in trench. The trench for buried system shall be a minimum of 18” wider than the preinsulated pipe and 36” deeper than the top of pipe. Trench bottom shall be stable, smooth and free of tones over ½-inch in diameter. Provide a minimum of 4” of sand bending prior to installation of pipe. Where heavy traffic is not expected, backfilled with “one-sack/sand surry” to 12” above the top of the conduit. The balance of the trench shall be backfilled with virgin soil previously removed from the trench. Mechanically compact soil in 6-inch layers to 95% compaction.

C. Insulation of straight joints: After welding and testing, all joints shall be insulated and sealed as per manufacturer’s standard procedures.

3.6 FIELD QUALITY CONTROL

A. General: The Owner's Representative shall conduct field inspections and witness all field tests specified in this Section. The Contractor shall perform field tests and provide labor, equipment, and incidentals required for testing. The Contractor shall produce evidence, when required by the Owner's Representative, that any item of work has been constructed properly in accordance with the Drawings and Specifications.

B. Installation Inspection by Insulation Manufacturer
   1. A fully qualified and certified representative shall be present during all crucial periods of the installation of the underground distribution system. Crucial periods of installation shall be defined as periods which include one or more of the following types of work:
      a. Inspection upon unloading.
      b. Inspection of trench prior to laying conduit.
      c. Inspection of concrete anchor blocks.
      d. Hydrostatic test of all service lines.
      e. Field joint closure work.
      f. Air test of conduit.
      g. Repair of any coating patch work.
      h. Holiday test of conduit coating.
      i. Initial backfill up to 10 inches above top of conduit casing.
   2. Reports to Construction Manager: A daily written report shall be prepared by the conduit manufacturer installation representative during the inspection periods. The report shall be prepared in triplicate form with the original and one copy to the contractor, and one copy retained by the manufacturer. The contractor shall be responsible for forwarding the original copy to the Contracting Officer. The report shall state whether or not the condition and quality of the material used and the installation of the system are in accordance with the plans and specifications, and are satisfactory. The report shall also note weather conditions, work in progress, field alterations, work on materials not in conformance with specification and remedial actions taken or recommended. Any known conditions that could result in an unsatisfactory installation shall also be noted.
   3. Certification: Upon satisfactory completion of the installation, the insulation manufacturer shall provide the installing contractor certification that the materials have been installed in accordance with the insulation manufacturer's approved brochure, plans and specifications. Certification of installation shall not be issued until any wet portions of the system have been dried.
   4. The contractor shall coordinate the following items with the insulation manufacturer
      a. Insulation system product description.
      b. Drying of Insulation.
      c. Drawings and part numbers.
      d. Unloading, handling and storage.
      e. Minimum trenching dimensions.
      f. Height of cover and backfilling.
      g. Recommended laying of units.
      h. Field joint insulating and welding procedure.
      i. Building or manhole wall entry.
      j. Minimum anchor block sizes.
      k. Altering units in the field.
      l. Conduit air test procedure.

m. Test cap for open end conduit.
n. Field joint coating procedure and holiday testing.

5. Recommendations for trenching and backfilling are to be followed unless superseded by instructions issued in the specifications.

C. Field Tests

1. Flushing: Just prior to pressure and hydrostatic testing, the pipe system shall be flushed with fresh water until piping is free of dirt and foreign matter.
2. Piping Hydrostatic Pressure Tests
   a. Where concrete thrust blocks have been provided, testing shall not begin on any section of pipeline until at least 5 days after placing of the concrete. Test pressure gauges for a specific test shall have dials indicating not less than 1-1/2 times nor more than 2 times the test pressure.
   b. After installation of insulation, casing, or jackets, anchor blocks, backfill, and flushing, hydrostatic pressure shall be applied to 200 psig and allowed to stabilize to ground temperature while maintaining 200 psig, plus or minus 10 psi. After stabilization, pressure source shall be removed. Piping must hold 200 psig, plus or minus 10 psi, for at least 4 hours. Leaks shall be repaired and test repeated.
3. Test conduit as follows:
   a. Seal vents and drains and subject conduit to 15 psig for four hours with no loss of pressure. Repair leaks and retest as required.

D. Cleaning: After testing, flush pipe with a cleaning solution as described in Section 232113 – HYDRONIC PIPING.

E. Operational Tests: After completion of the system, or a testable portion thereof, the system shall be operated for not less than 6 hours at operational temperatures and pressures to demonstrate satisfactory function.

END OF SECTION

SECTION 232123
HYDRONIC PUMPS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Close coupled, base-mounted, end-suction centrifugal pumps.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.3 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   1. Wiring Diagrams: Power, signal, and control wiring.

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

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Section 016000 – PRODUCT REQUIREMENTS.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Owner's Representative and marked for intended use.

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

E. Each pump with motor in 5hp or larger shall be factory tested per Hydraulic Institute Standards prior to shipment. Pump selections with flat curves shall not be permitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal(s) for each pump.

1.8 WARRANTY

A. Manufacturer agrees to repair or replace pump that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

2.2 CLOSE COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers
   1. Bell & Gossett; Div. of ITT Industries.
   2. Armstrong Pumps Inc.
   3. Taco, Inc.
   4. Or equal.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175 psig minimum working pressure and a continuous water temperature of 225 degrees F.

C. Pump Construction

D. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections.
   1. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw.
   2. Pump Shaft: Stainless steel.
   3. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.
   4. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

E. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36 / A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

F. Bearings shall be selected for a minimum L10 life of 200,000 hours at maximum catalogued operating speed.

G. Motor: Single speed and rigidly mounted to pump casing with integral pump support.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
      a. Enclosure: Totally enclosed, fan cooled.
      b. Enclosure Materials: Cast iron.
      c. Motor Bearings: Permanently lubricated ball bearings.
      d. Efficiency: Premium efficient.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Section 230500 – COMMON WORK RESULTS FOR HVAC.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Comply with HI 1.4 for centrifugal pumps

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

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

D. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

E. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

G. Support pump fittings with floor mounted pipe and flange supports.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, non-metallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

G. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve, shut off valve and balancing valve on pump discharge, balancing valve shall be omitted on pumps with variable speed drives.

H. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For in-line, close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.

I. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

J. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

K. Millwright, with minimum 10 years experience in the trade, shall check, align and certify base mounted pumps prior to start-up and certification provided.

3.6 STARTUP SERVICE

A. Check piping connections for tightness.

B. Clean strainers on suction piping.

C. Perform the following startup checks for each pump before starting:

1. Verify bearing lubrication.
2. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

3. Verify that pump is rotating in the correct direction.

D. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

E. Start motor.

F. Open discharge valve slowly.

3.7 DEMONSTRATION

A. Train the Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Section 017900 – DEMONSTRATION AND TRAINING.

END OF SECTION

SECTION 232300
REFRIGERANT PIPING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air conditioning applications.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig.
   2. Suction Lines for Heat Recovery Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Hot-gas bypass valves.
   4. Filter dryers.
   5. Strainers.
   6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   1. Shop Drawing Scale: 1/4-inch equals 1 foot.
   2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Welding certificates.

D. Field quality-control test reports.

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

F. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.6 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations.

PART 2 PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Flare nuts required on suction lines shall be of short forged or “frostproof” type.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig.
   5. Maximum Operating Temperature: 250 degrees F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves
   1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
   3. Operator: Rising stem and hand wheel.
   4. Seat: Nylon.
   5. End Connections: Socket, union, or flanged.
   6. Working Pressure Rating: 500 psig.
   7. Maximum Operating Temperature: 275 degrees F.

B. Packed-Angle Valves
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: Rising stem.
   4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
   5. Seal Cap: Forged-brass or valox hex cap.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Working Pressure Rating: 500 psig.
   8. Maximum Operating Temperature: 275 degrees F.

C. Check Valves
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   3. Piston: Removable polytetrafluoroethylene seat.
   4. Closing Spring: Stainless steel.
   5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
   6. End Connections: Socket, union, threaded, or flanged.

7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 degrees F.

D. Service Valves

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115 V-ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 degrees F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 degrees F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 degrees F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115 V-ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 degrees F.

I. Straight Type Strainers

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.

4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 degrees F.

J. Angle Type Strainers
   1. Body: Forged brass or cast bronze.
   2. Drain Plug: Brass hex plug.
   3. Screen: 100-mesh monel.
   4. End Connections: Socket or flare.
   5. Working Pressure Rating: 500 psig.
   6. Maximum Operating Temperature: 275 degrees F.

K. Moisture / Liquid Indicators
   1. Body: Forged brass.
   2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
   3. Indicator: Color coded to show moisture content in ppm.
   4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
   5. End Connections: Socket or flare.
   6. Working Pressure Rating: 500 psig.
   7. Maximum Operating Temperature: 240 degrees F.

L. Replaceable Core Filter Dryers: Comply with ARI 730.
   1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina or charcoal.
   4. Designed for reverse flow (for heat-pump applications).
   5. End Connections: Socket.
   6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
   7. Maximum Pressure Loss: 2 psig.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 240 degrees F.

M. Permanent Filter Dryers: Comply with ARI 730.
   1. Body and Cover: Painted-steel shell.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina or charcoal.
   4. Designed for reverse flow (for heat-pump applications).
   5. End Connections: Socket.
   6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
   7. Maximum Pressure Loss: 2 psig.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 240 degrees F.

N. Mufflers
   1. Body: Welded steel with corrosion-resistant coating.
   2. End Connections: Socket or flare.
   3. Working Pressure Rating: 500 psig.
   4. Maximum Operating Temperature: 275 degrees F.

O. Receivers: Comply with ARI 495.
   1. Comply with UL 207; listed and labeled by an NRTL.
   2. Body: Welded steel with corrosion-resistant coating.
   3. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
   4. End Connections: Socket or threaded.
   5. Working Pressure Rating: 500 psig.
   6. Maximum Operating Temperature: 275 degrees F.

P. Liquid Accumulators: Comply with ARI 495.
   1. Body: Welded steel with corrosion-resistant coating.
   2. End Connections: Socket or threaded.
   3. Working Pressure Rating: 500 psig.
   4. Maximum Operating Temperature: 275 degrees F.

2.3 REFRIGERANTS

A. Manufacturers:
   1. Honeywell, Inc.; Genetron Refrigerants.
   2. Or equal.

B. ASHRAE 34, R-410A: Mixture of Pentafluoroethane and Difluoromethane.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 3 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat Pump Applications
   1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
   2. NPS 1 1/4 to NPS 2: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping
   1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
   2. NPS 1-1/4 to NPS 2: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

B. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

C. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

D. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

E. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

F. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

G. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

H. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.

2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

I. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

J. Install receivers sized to accommodate pump-down charge.

K. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

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

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

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

G. Install piping free of sags and bends.

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

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Sections 230923 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC and 230960 – SEQUENCE OF OPERATIONS FOR HVAC Controls for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 – ACCESS DOORS AND FRAMES, if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Refrigerant piping shall be cased piping system where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.

3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. 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.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

S. Seal penetrations through fire and smoke barriers according to Section 078413 – PENETRATION FIRE STOP SYSTEMS.

T. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

U. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

V. Seal pipe penetrations through exterior walls according to Section 079200 – JOINT SEALERS for materials and methods.

W. Identify refrigerant piping and valves according to Section 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BCuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

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

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.

B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4-inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4-inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4-inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8-inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8-inch.

6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8-inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8-inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2-inch.

D. Support multi-floor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. All refrigerant systems shall be triple evacuated and purged with nitrogen, before refrigerant charging of such systems. Systems shall be leak checked and hold a 500 micron vacuum or better for a minimum of 24 hours and a nitrogen holding charge of 100 psi over normal operating pressures for a minimum of 24 hours.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections
1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

3.9 TESTING REPORT SHEETS

A. VRF System Air Conditioning R-410A Testing Report Sheet

Test	Time of Test Start	Required Pressure or Vacuum	Actual Initial Pressure PSIG or Vacuum Microns	Initial Test Witnessed By	Required Test Duration	Time of Test Completion	Allowable Final Pressure or Vacuum	Final Actual Pressure PSIG or Vacuum Microns	Contractor Test Verification Signature	Owner Inspection Services or PM Engineer Final Test Witnessed By
1		1500 microns			1 hour min. 4 hours max.	N/A	2000 microns			
2		550 PSIG Nitrogen			1 hour min. 4 hours max		550 PSIG Nitrogen			
3		1000 microns			1 hour min. 4 hours max		1500 microns		N/A	
4		1500 PSIG Nitrogen		N/A	N/A		N/A	N/A		N/A
5		500 microns			24 hours		500 microns		N/A	

1. Tests 1, 2, 3 and 5 shall be witnessed by Owner’s Representative.
2. Test period is at the discretion of the Owner’s Representative.
3. Contractor test verification (Tests 4) shall be confirmed and signed by Contractor.
4. Any failure of pressure or vacuum tests at any of the stages will trigger a complete retest of the refrigeration system beginning at Test 1.

END OF SECTION

SECTION 232500
HVAC WATER TREATMENT

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following HVAC water-treatment systems:
   1. Bypass chemical-feed equipment and controls.
   2. Chemical treatment test equipment.
   3. HVAC water-treatment chemicals.
   4. Water filtration units for HVAC makeup water.

1.2 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. RO: Reverse osmosis.

D. TDS: Total dissolved solids.

1.3 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including but not limited to hot-water heating, shall have the following water qualities:
   1. pH: Maintain a value within 9.0 to 10.5.
   2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
   3. Boron: Maintain a value within 100 to 200 ppm.
   4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
   5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
   6. TDS: Maintain a maximum value of 10 ppm.
   7. Ammonia: Maintain a maximum value of Insert number ppm.
   8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
   9. Microbiological Limits:
      a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
      b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
      c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
      d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
      e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
   1. Bypass feeders.

B. Shop Drawings: Pretreatment and chemical, treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports.

D. Manufacturer Seismic Qualification Certification: Submit certification that water filtration units and components will withstand seismic forces defined in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT. Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For sensors, injection pumps, water filtration units, and controllers to include in emergency, operation, and maintenance manuals.

F. Other Informational Submittals:
   1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
   2. Water Analysis: Illustrate water quality available at Project site.
   3. In accordance with project submittal requirements, submit a proposed schedule for routine treatment control and reporting for all affected systems for the entire year.
   4. Submit reports indicating that the piping systems have been properly cleaned, and that start-up of all treatment systems has been completed, and all systems are operating properly.
   5. Submit reports indicating initial analysis and status of system water after cleaning, and after charging of treatment chemicals.
   6. Submit monthly status reports, with a copy to the Owner’s Representative indicating all findings on jobsite visits, chemical residual balances and any chemicals added, including quantities for the record. Note any discrepancies including leakage which may be causing chemical residuals to decay faster than normal and equipment which is not working properly. Note maintenance procedures which could be improved if needed so that the program can be optimized.
   7. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Owner’s Representative.

1.5 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

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

1.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for hot-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
   1. Initial water analysis and HVAC water-treatment recommendations.
   2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
   3. Periodic field service and consultation.
   4. Customer report charts and log sheets.
   5. Laboratory technical analysis.
   6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

B. Provide monthly technical service visits to perform field inspections and make water analysis on site.

C. Service Companies
   1. Chem-pro.
   2. Or equal.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anderson Chemical Co, Inc.
   2. Aqua-Chem, Inc.; Cleaver-Brooks Div.
   3. GE Betz.
   4. H-O-H Chemicals, Inc.
   5. ONDEO Nalco Company.
   6. Or equal.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
   1. Capacity: 5 gal.
   2. Minimum Working Pressure: 125 psig.

2.3 STAINLESS-STEEL PIPES AND FITTINGS

A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.

B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig SWP and 600-psig CWP ratings.

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. The water treatment contractor shall provide all necessary and proper chemicals to operate the systems for a period of two years from initial operation. The following shall be included:
   1. Cleaning chemicals, in liquid form, for cleaning of the system.
   2. Systems shall be treated with a borate nitrite compound. The following residuals shall be maintained:
      a. 600-800ppm nitrite in hot water heating systems.
      b. 400-600ppm nitrite in chilled water systems.
   3. Biocide
      a. Supply and install chemicals as recommended for the local water quality.

PART 3 EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, equipped with the following:
   1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
   2. Install water meter in makeup water supply.
   3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
   4. Install a full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
   5. Install a swing check on inlet after the isolation valve.

3.3 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 equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 230500 – COMMON WORK RESULTS FOR HVAC.

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 – GENERAL DUTY VALVES FOR HVAC PIPING.

E. Refer to Section 221119 – DOMESTIC WATER PIPING SPECIALTIES, for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

H. Connect wiring according to Section 260519 – LOW VOLTATE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.4 CLEANING SEQUENCE

A. Prior to system fill disconnect flexible hoses at each coil and connect together to bypass coil. Continue with hoses in this configuration until system has been completely flushed and cleaned when coils shall be reconnected.

B. Add cleaner to open and closed systems at concentration as recommended by manufacturer but not less than one pound per 100 gallons of water for hot systems and one pound per 50 gallons of water for cold systems.

C. Cooling and Heating Systems: Circulate for 48 hours, then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.

D. Flush the system of all pipe slag and particulate matter.

E. Fill the system with hot water (140°F) and add a solution of hypochlorite as recommended by the manufacturer. Circulate the system for 24 hours. Blowdown and clean out all the strainers.

F. Drain the system and fill with required water.

G. Use neutralizer agents on recommendation of system cleaner supplier.

H. Flush open systems with clean water for one hour minimum. Drain completely and refill.

I. Remove, clean, and replace strainer screens.

J. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising the Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

F. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Article 1.4 above.

G. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain HVAC water treatment systems and equipment. Refer to Section 017900 – DEMONSTRATION AND TRAINING.

END OF SECTION

SECTION 233113
METAL DUCTS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes metal ducts for supply, return, outside, relief and exhaust air-distribution systems in pressure classes from minus 6- to plus 10-inch wg. Metal ducts include the following:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   3. Sheet metal materials.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.
   7. Seismic-restraint devices.
   8. Related Sections include the following:
   9. Section 230000 – BASIC MECHANICAL REQUIREMENTS
   10. Section 230500 – COMMON WORK RESULTS FOR HVAC
   11. Section 230700 – HVAC INSULATION
   12. Section 233300 – AIR DUCT ACCESSORIES
   13. Section 233713 – DIFFUSERS, REGISTERS, AND GRILLES
   14. Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC
   15. See Commissioning Requirements Section 019113.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 REFERENCE STANDARDS

A. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel.

B. ASTM A 240/A 240M - Standard Specification for Chromium and Chromium-Nickel Stainless

C. Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.

D. ASTM A 480/A 480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

E. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

F. ASTM A 1008/A 1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength, Low Alloy, and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

G. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

H. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

I. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.

J. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

K. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association.

L. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association.

M. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; National Fire Protection Association.

N. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association.

O. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association.

P. SMACNA (DC) – Duct Cleanliness for New Construction Guidelines; Sheet Metal and Air Conditioning Contractors' National Association.

1.3 PERFORMANCE REQUIREMENTS

A. Refer to Section 230548 – VIBRATION AND SEISMIC CONTROL FOR HVAC, for wind and seismic loading requirements.

B. Delegated Duct Design: Duct construction, including sheet metal thicknesses (minimum 24 gauge), seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article unless noted otherwise in Part 2.

C. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.

1.4 DEFINITIONS

A. NUSIG: National Uniform Seismic Installation Guidelines.

1.5 ACTION SUBMITTALS

A. Shop Drawings: CAD-generated and prepared in accordance with the requirements of Section 230000 – BASIC MECHANICAL REQUIREMENTS. Show fabrication and installation details for metal ducts. Shop drawing shall include plans, elevations, sections, and details as necessary to adequately describe the installation.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work. Duct layout indicating sizes and pressure classes (net outside dimensions with liner thickness indicated where required.).
2. Elevations of top and bottom of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Fittings.
5. Reinforcement and spacing.
6. Seam and joint construction.
7. Penetrations through fire-rated and other partitions.
8. Equipment installation based on equipment being used on Project.
9. Duct accessories, including access doors and panels.
10. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
11. HVAC Equipment (Air Handlers, Air Terminals, Coils, etc.).
12. Required Electrical Access or Service Clearances for HVAC Equipment.
13. Diffusers, Registers or Grilles with size and airflows indicated.

B. Delegated-Design Submittal

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing (unless noted otherwise in Part 2).
3. Reinforcement details and spacing (unless noted otherwise in Part 2).
4. Materials, fabrication, assembly, and spacing of hangers and supports.

5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 – "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4- HVAC system Construction and Insulation.
3. Leakage Test report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2- Duct Leakage Tests.
4. Duct Cleaning Test report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4- Ventilation System Start-up.
5. Product Data for Credit IEQ 4.1: For adhesive and sealants, documentation including printed statement of VOC content.
6. Laboratory Test reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services – Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved

1. Structural members to which duct will be attached.
2. Size and location of initial access modules for acoustical tile.
3. Penetrations of smoke barriers and fire-rated construction.
4. Items penetrating finished ceiling including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. As-Built Documents: Refer to Section 017839, PROJECT RECORD DOCUMENTS.

B. Duct Leakage Test Reports – one per project.

1.8 QUALITY ASSURANCE

A. Welding

1. Standards: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
2. Submit certification of satisfactory performance testing for all welders and welding operators, which provide welding services for the project. All welders shall be American Welding Society (AWS) or LA certified. Welding procedures shall be per AWS.
3. Submit the written corporate Quality Control Manual to ensure compliance with specification requirements.

4. Welders shall utilize appropriate safety equipment, eye protection, screens, fire suppression equipment, and fume extraction equipment (when welding is being performed within occupied buildings or finished spaces).
5. Weld joints with a minimum joint penetration of 75% as indicated in SMACNA "Rectangular Industrial Duct Construction Standard". Where more complete Joint Penetration is required, it shall be as coordinated with the Owner's Representative.

B. NFPA Compliance

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

D. All ductwork shall be constructed, erected and tested in accordance California Mechanical Code and SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2005, third edition requirements.

1.9 DELIVERY, STORAGE AND HANDLING

A. To protect cleanliness of the ductwork in preparation for shipping from the fabrication facility shrink wrap openings of ducts with duct liner. Alternatively, tarp shipping basket at factory prior to shipment. Maintain tarp on basket at site as components are pulled for installation.

B. Consignee must inspect shipment upon delivery and note any and all damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

C. To protect cleanliness of the ductwork in preparation for shipping from the fabrication facility wrap openings of ducts. The Contractor shall coordinate these requirements with the Owner and fabrication facility.

D. Ducts shall be staged in a lay down area facilitated by the Contractor for the job-site conditions. If sufficient lay down area is not available on-site and off-site storage is required, such additional provisions shall be coordinated by the Contractor.

E. Protect (cover) openings of duct at the end of the workday to protect ductwork from dust or animal migration into ducts.

F. All adhesive advertisement or company logos should be removed from duct before shipping.

G. Protect coated duct from damage due to normal handling during shipment and storage. Protection shall be applied to ends of duct to prevent dirt and moisture from entering ducts and fittings.

H. Coated duct shall not be stored in an area where it will have a chance to be damaged from traffic or debris. All coated duct shall be stored on cardboard, Styrofoam or similar materials. Where possible, store inside and protect from dirt and debris. When it is necessary to store coated duct outside, store above grade and enclose with waterproof wrapping to protect from dirt and debris.

I. If coating is scratched during shipping or handling, contact the manufacturer for approved repair procedures.

PART 2 PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless-steel Sheets: Comply with ASTM A480/A 480M, 18-8 Stainless Steel Type 316, as indicated in the Duct Schedule article, cold rolled, annealed sheet, 18 gauge. Exposed surface finish shall be No. 2B, No. 2D, No.3 or No.4 as indicated in the Duct schedule article. All joints, seams and connections shall be continuously heliarc welded with 18-8 stainless steel rod type 318-ELC. Elbows and angles shall have the same gauge as ductwork, inside radius not less than width of duct.

D. Reinforcement Shapes and Plates: ASTM A36/A 36M, steel plates, shapes and bars,galvanized.

1. Where galvanized steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with neoprene or EPDM gasket materials.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

F. Fasteners: Rivets, bolts, or sheet metal screws.

2.2 DUCT LINER

A. General Requirements

1. Duct liner shall not impart any odor to the air, nor should it delaminate or loosen by the airstream during operation. Air friction correction factor shall not exceed 1.05 at 2,000 fpm and 1.2 at 400 fpm. Acoustical liner that becomes damaged during shipment or installation shall be replaced at no cost to the Owner.
2. Duct liner shall be terminated with a metal nosing such that no exposed edges are exposed to the air stream.
3. Duct liner shall be installed in accordance with SMACNA “HVAC Duct Construction Standards--Metal and Flexible”.
4. Duct Liner shall be used only as indicated on the drawings and on all ducts exposed to weather. All remaining ducts shall be externally wrapped.
5. Protect liner with perforated 3/32 inch diameter hole, (open area of 23 percent) 26 gage sheet metal liner. Secure to duct without compressing insulation.
6. Nosing: Nosing may be formed from a channels or “J” shape attached to the duct with screws, rivets, or tack welds. Alternatively, nosing may be integrally formed to duct Nosing shall be provided when duct velocities exceed 1,500 fpm.

B. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Manufacturers
   a. CertainTeed Corp.; Insulation Group.
   b. Johns Manville International, Inc.
   c. Knauf Fiber Glass GmbH.
   d. Owens Corning.
   e. Or equal.
2. Materials: ASTM C 1071; surfaces exposed to air stream shall be coated to prevent erosion of glass fibers.
   a. Thickness: 1 inch indoors and 2 inches outdoors or as indicated on the Drawings.
   b. Thermal Conductivity (k-Value): 0.27 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   e. 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.
      1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
      2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
      3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
   f. Anti-Microbial Agent: EPA registered so it will not support the growth of fungus or bacteria, and is water repellent.
   g. Noise Reduction Criteria (NRC) Tested per ASTM C 423 – type A mounting:

1) 0.55 for 0.5 inch
2) 0.70 for 1.0 inch
3) 0.90 for 1.5 inch
4) 1.00 for 2.0 inch

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Sealant
   1. Manufacturers: Provide products by the following:
      a. Hardcast 321.
      b. MEI Eco-Duct 44-52 (Water Based Formula).
      c. Sikaflex-1a (High Purity Duct Sealant).
      d. Vulkem 116 (Utilize on Exterior Exposed Duct).
      e. Or equal.
   2. Type: Non-hardening, water resistant, mildew and mold resistant. Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and as recommended by manufacturer for pressure class of ducts.
   3. Must be LEED approved product.

D. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

E. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other complying 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 class.
   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", 2005, third edition.

B. Ducts, elbows, transitions, offsets, branch connections, and other constructions shall be per SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2005, third edition, except for the following:
   1. Fig. 2-2 Longitudinal Seams-Rect. Duct – Button punch snap lock is not acceptable. Use Pittsburgh lock 3/8-inch minimum pocket for rectangular ducts.
   2. Fig. 4-3 Vanes and Vane Runners – Double thickness vanes. Single vanes with trailing edge are acceptable. Trailing edge length shall be 3 times the vanes spacing.
   3. Fig. 4-6 Branch Connections – Straight Tap, Butt Flange and Dovetail joint are not acceptable. Use 45° entry clinch lock. Use conical or bellmouth branch connections for round ducts.
   4. Fig. 7-2 Duct Access Doors – Use continuous piano hinge in lieu of butt hinge.
   5. Fig. 7-3 Access Doors-Round Duct – Split Sleeves are not acceptable.
   6. Fig. 4-2 Rectangular Elbows – Type RE-1 radius elbow shall always be used when space permits. Square throat elbows with double wall vanes (single vanes with trailing edge are acceptable) may be used for supply ducts when space is limited.
   7. Fig. 3-2 Round Duct Longitudinal Seams – Snap lock seam is not acceptable.
   8. Fig. 3-1 Round Duct Transverse Joints – RT-3 Drawband joint and RT-5 Crimp Joint are not acceptable. Use RT-1 Beaded Sleeve Joints.
   9. Fig. 3-4 Round Duct Elbows – Pleated and Adjustable Elbow are not acceptable. Adjustable elbow may be used in duct pressure under 1-inch static pressure, provided sheet metal straps and screws are installed to lock elbow position and all joints and seams are sealed.
   10. Fig 3-5 90° Tees and Laterals – 90° Tap and Saddle Tap are not acceptable. Use 45° laterals or Conical Tees shown on Fig 3-6.

11. Fig. 3-10 and 3-11 Flexible Duct Supports – Use 4-inch wide band in lieu of 1-inch band straps.
12. Fig. 5-2 Upper Attachment Devices-Typical – Details 1, 3b, 4, 5, 7, 9, 10-, 11, and 14 are not acceptable.
13. Fig. 5-4 Upper Attachments – Typical - This detail is not acceptable.
14. Fig 7-11 Flexible Duct Liner Installation – Use only metal weld pins and 100% area coverage of adhesives. This also applies to rigid duct liners.

C. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers
   a. Ductmate Industries, Inc.
   b. Nexus Inc.
   c. Ward Industries, Inc.
   d. Or equal.

D. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Manufacturers
   a. Ductmate Industries, Inc.
   b. Lockformer.
   c. Or equal.
2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

E. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359-inch thick or less, with more than 10 sq ft of nonbraced panel area unless ducts are lined.

2.5 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive 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 liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

G. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations

1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.

H. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

I. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

K. Elastomeric duct liner shall not be used to insulate exterior ductwork.

2.6 DUCT HANGERS AND SUPPORTS

A. Verify attachment selection and spacing with licensed structural engineer registered in the state where the project resides.

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electro-galvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

D. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.7 SEISMIC RESTRAINT DEVICES

A. Manufacturers: Provide products by one of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Mason Industries.
6. TOLCO; a brand of NIBCO INC.
7. Unistrut Corporation; Tyco International, Ltd.
8. Or equal.

B. General Requirements for Restraint Components

1. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service.
2. Ductwork shall be supported and braced to resist all directional (transverse, longitudinal and vertical) forces.
3. Brace rectangular ducts with cross sectional areas of six square feet and larger. Brace round ducts with diameters of 28 inches and larger.
4. Provide devices meeting one of the following options:
   a. Design and installation to meet the criteria listed above, and meet requirements of the latest Sheet Metal and Air Conditioning Contractors National Association (SMACNA), Seismic Restraint Manual Guidelines for Mechanical Systems for the prescribed Seismic Hazard Level (SHL) AA, September 1998 with 2000 addendum 1.
   b. Design and installation to meet the criteria listed above, and meet the most current requirements of the National Uniform Seismic Installation Guidelines (NUSIG). Submit all design tables and information for the design force levels, stamped and signed by a licensed professional engineer registered in the state where the project resides.
   c. Where SMACNA or NUSIG requirements are not met completely, submit proposed alternate details and calculations to completely address seismic bracing requirements. Such designs shall use the California Building Code requirements for determining seismic forces, and be performed, stamped and signed by a California registered professional engineer.

C. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

D. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

E. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

F. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

G. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 EXECUTION

3.1 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", 2005, third edition, unless otherwise indicated.

B. The maximum change in direction allowed for a duct offset is 15 degrees unless specifically approved in writing by the Owner’s Representative.

C. Install round ducts in lengths not less than 12 feet unless interrupted by fittings.

D. Install ducts with fewest possible joints.

E. Install fabricated fittings for changes in directions, size, and shape and for connections.

F. Paint exposed roof mounted ductwork with color as specified in 099001 COLOR SCHEDULE.

G. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

H. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

K. Under no circumstances will any labels be permitted on interior surfaces of ductwork. Any materials delivered to the jobsite with interior labels shall be physically and chemically cleaned to remove all remnants of the tag and/or adhesive used to place it.

L. The top of all sheet metal ducts and plenums shall be crowned or sloped to prevent water ponding on top of the surface.

M. Where connecting flexible duct to metal duct the inner lining shall be placed a minimum of 6 inches over the metal. A zip tie shall be placed over the joint and the flexible duct collar attached with a minimum of three sheet metal screws with foil tape provided to seal the end. The duct insulation shall cover this assembly with the outer membrane covering the insulation and sealed with tape having an integral vapor barrier.

N. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

O. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

P. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

Q. Duct Tape is not permitted.

R. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

S. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

T. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Section 233300 – AIR DUCT ACCESSORIES. Firestopping materials and installation methods are specified in Section 078400 – FIRE SAFING – FIRE STOPPING.

U. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." and NUSIG.

V. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

W. All ducts 30 inches in diameter or 6 feet square area and greater and all ducts 20 feet 0 inches long and longer shall be seismically restrained.

X. Use double nuts and lock washers on all threaded rod supports.

Y. At exterior wall louvers, seal duct to louver frame. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Insulate unused portion of outside air intake or exhaust louvers, and duct to the insulated isolation damper. Blank-out material shall be same material as duct, painted black on exterior side. Install outside air intakes to pitch 1 inch per 20 feet toward intake louver where possible, provide a low point drain prior to equipment where intake duct must slope down from louver. Seal ducts seams to form watertight joints.

Z. When joining dissimilar non-compatible metal duct materials, provide flanged joint with gaskets to provide a dielectric break. Dissimilar but compatible metals are not required to have dielectric breaks, such as stainless steel to carbon steel.

AA. Where original galvanized surface finish is compromised, apply a field coat of cold galvanizing material, ZRC Products Incorporated or equal; prior to application, ensure surface is properly prepared without surface rust, paint, or debris.

BB. Duct Penetrating Wall Assemblies

1. Non-fire Rated Wall Penetrations - When ducts which are exposed to view penetrate wall assemblies, provide a fabricated escutcheon to conceal space between construction opening and duct. Overlap construction opening by 1-1/2 inch minimum.
2. Fire-Rated Wall Penetrations – When ducts penetrate rated wall assemblies, provide the appropriate damper assembly as identified on the design documents. Install fire dampers, smoke dampers, or fire/smoke dampers in accordance with manufacturer's installation instructions. Refer to 078400 FIRE SAFING – FIRE STOPPING, for additional requirements.

3.2 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," 2005, third edition for duct pressure class indicated.

B. Each duct transverse joint and longitudinal seam shall be sealed airtight using UL listed duct sealant in accordance with SMACNA Table 1-1 Duct Sealing Class A Requirements.

C. Seal ducts before external insulation is applied.

D. Refer to Paragraph 3.8 below for seal class.

3.3 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured. Powder-actuated fasteners are only approved for the support of flex duct.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

A. Make connections to air moving equipment with flexible connectors according to Section 233300 – AIR DUCT ACCESSORIES.

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT LINER

A. Use single layer of liner to achieve required thickness. Provide thickness per design documents.

B. Line complete surface of duct section designated to include liner. Multiple sections of liner may be jointed and butted together to form fully lined sections of duct. Neatly butt transverse or longitudinal joints, without interruptions, gaps, or exposed liner edges. Coat joint with adhesive.

C. All edges of cut liner shall be sprayed with adhesive to prevent disengagement of sound lining fibers.

D. Fold and compress liner in corner of rectangular duct sections, or cut and fit to ensure butted edge overlaps.

E. Terminate liner prior to dampers, coils, fire/smoke dampers, and as indicated on plans.

F. Liner Attachment

1. Apply adhesive on liner to adhere to duct with 90 percent coverage on the contact surface area. Utilize pin spacing in accordance with SMACNA requirements.
2. Welded pin with integral or press-on head.
3. When weld-on pins are not practical tack weld perforated backed pins to duct.
4. Stick pins (adhered) are not allowed.

G. Nosing

1. Provide on leading edge facing airflow, not required on trailing edge, and not required at intermediate liner joints between duct sections or liner sections.
2. Provide whenever liner is preceded by unlined metal duct
3. Provide at fan discharge.

3.7 FIELD QUALITY CONTROL

A. Leakage Tests

1. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports
2. Test the following Systems
    a. Ducts with a Pressure Class Higher than 3-inch wg: Test all duct sections.
    b. Laboratory exhaust and fume hood exhaust systems: Test all duct sections.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes 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.
6. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
7. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

B. Laboratory Exhaust and Fume Hood Exhaust System Duct Leakage Test

1. When pre-testing is complete and before any exhaust duct enclosure is constructed, the Contractor shall demonstrate to the Owner’s Representative that a liquid tight condition (zero leakage) as identified in NFPA-96, 3.3.36 has been obtained. The following leak test procedure shall be implemented.
    a. Temporary cap and seal all openings.
    b. Testing procedure shall be to induce a minimum of 6 inches WC or 1.25 times the system static pressure, whichever is larger, inside the duct using an air compressor and schrader valve.
    c. When pressure has stabilized at test pressure, for a period of 5 minutes, the test pressure must be held without any noticeable drop in pressure as shown on a digital manometer for the system to pass.
    d. The test shall show no more than 0% leakage.
    e. The above test shall be completed and verified by the Owner’s Representative prior to the installation of the drywall enclosure or duct wrap.

C. Duct System Cleanliness Tests
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner's Representative, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

3.8 DUCT CLEANING

A. New ducts systems that do not pass the duct system cleanliness test described in section 3.7BC shall be cleaned in accordance with this specification section before testing, adjusting, and balancing

B. Clean new and existing duct system(s) before testing, adjusting, and balancing.

C. Particulate Collection and Odor Control
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   4. Coils and related components.
   5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   6. Supply-air ducts, dampers, actuators, and turning vanes.
   7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
   5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
   6. Provide drainage and cleanup for wash-down procedures.
   7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Ducts shall be protected during construction, transportation, storage at the construction site, and installation in accordance with requirements for Advanced Level of current SMACNA Duct Cleanliness for New Construction" standards.

G. Comply with requirements of ASHRAE 62.1-2013, Section 7.2.4 - "Ventilation System Start-Up" for LEED Prerequisite EQ 1.

H. Stored on-site and installed absorptive materials shall be protected from moisture damage.

I. Cleanliness Verification
   1. Where contaminants are discovered, clean and re-inspect ducts.

3.9 START UP

A. Air Balance: Comply with requirements in Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts
   1. Supply Ducts
      a. Pressure Class: Positive 3-inch wg.
      b. Minimum SMACNA Seal Class: B.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round: 6.

C. Return Ducts
   1. Return Ducts
      a. Pressure Class: Positive or negative 3-inch wg.
      b. Minimum SMACNA Seal Class: B.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round: 6.

D. Exhaust Ducts
   1. Ducts Connected to Environmental Exhaust Fans
      a. Pressure Class: Negative 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.
   2. Fume Hood/Snorkel Exhaust Ducts
      a. Type 316 Stainless Steel sheet, minimum 18 gauge.
         1) Exposed to View: No.4 finish.
         2) Concealed: No.2B finish.
      b. Pressure Class: Negative 4-inch wg.
      c. Minimum SMACNA Seal Class: A.
      d. SMACNA Leakage Class for Rectangular: 6.
      e. SMACNA Leakage Class for Round and Flat Oval: 3.
   3. General Laboratory exhaust at roof level (ASHRAE 62.1, Class 3 and 4) Air
      a. Type 316 Stainless Steel sheet, minimum 18 gauge.
         1) Exposed to View: No.4 finish.
         2) Concealed: No.2B finish.
      b. Pressure Class: Negative 4-inch wg.
      c. Minimum SMACNA Seal Class: A.
      d. SMACNA Leakage Class for Rectangular: 6.
      e. SMACNA Leakage Class for Round and Flat Oval: 3.
   4. General Laboratory exhaust inside the building (ASHRAE 62.1, Class 3 and 4) Air
      a. Pressure Class: Negative 4-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.
   5. Laser Cutter Exhaust Ducts (ASHRAE 62.1, Class 1 and 2) Air
      a. Pressure Class: Negative 10-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts

1. Ducts Connected to Air-Handling Units
    a. Pressure Class: Positive or negative 3-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.
2. Ducts Connected to Equipment Not Listed Above
    a. Pressure Class: Positive or negative 3-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 6.
    d. SMACNA Leakage Class for Round and Flat Oval: 3.

F. Intermediate Reinforcement

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. Stainless- Steel Ducts: Match duct material.

G. Liner

1. Supply Air Ducts Outdoors: Fibrous glass, Type I or Flexible elastomeric, 2 inches thick.
2. Return Air Ducts Outdoors: Fibrous glass, Type I or Flexible elastomeric, 2 inches thick.

H. Elbow Configuration

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
    a. Velocity 1000 fpm or Lower
        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.
    b. Velocity 1000 to 1500 fpm
        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
    c. Velocity 1500 fpm or Higher
        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
        1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
        3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or Segmented.
    c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

I. Branch Configuration

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
    a. Rectangular Main to Rectangular Branch: 45-degree entry. Straight taps are not permitted.
    b. Rectangular Main to Round Branch: Conical or bell mouth. Flanged or straight taps are not permitted.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are not permitted.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Backdraft dampers.
   2. Barometric relief dampers.
   3. Manual volume dampers.
   4. Control dampers.
   5. Combination fire and smoke dampers.
   6. Seismic expansion joint.
   7. Sound Attenuators.
   8. Remote damper operators.
   9. Turning vanes.
   10. Duct-mounting access doors.
   11. Flexible connectors.
   12. Flexible ducts.
   13. Draft gauges.
   14. Duct accessory hardware.

B. Related Sections include the following:
   1. Section 23 09 23 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.
   2. Division 28 Section "Fire Detection and Alarm" for duct-mounting fire and smoke detectors.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Backdraft dampers.
   2. Barometric relief dampers.
   3. Volume dampers.
   4. Combination fire and smoke dampers.
   5. Sound Attenuators.
      a. Acoustical and Aerodynamic Test Data: Submit the following data in tabular form for the Manufacturer's standard proposed product:
         1) Sound trap type and size.
         2) Maximum pressure drop at required air volume.
         3) Dynamic insertion loss in octave bands centered at 63Hz through 8000Hz for both forward and reverse flow conditions. Dynamic insertion loss shall be determined in accordance with the latest edition of ASTM E 477 or a test standard approved by the Owner's Representative.
         4) Self-noise sound power levels in same octave bands as above. Self-noise shall be determined in accordance with the latest edition of ASTM E 477 or a test standard approved by the Owner's Representative.
      b. Specifications: Submit Manufacturer's specifications and other data needed to prove compliance with all specified requirements.
      c. Installation Instructions: Submit Manufacturer's recommended installation instructions and procedures.
      d. Exceptions: Identify all proposed changes, differences and/or discrepancies, including verbiage, terms and definitions between Contract Documents and submittals.

6. Turning vanes.
7. Duct-mounting access doors.
8. Flexible connectors.
9. Flexible ducts.

B. LEED Submittals

1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
2. Manual-volume damper installations.
3. Combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
4. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

B. Submit proof of manufacturer's qualifications specified in "Quality Assurance" below.

1.4 CLOSEOUT SUBMITTALS

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

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

B. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems," NFPA 80, "Fire Doors and Other Opening Protectives," and NFPA 105, "Smoke Door Assemblies and Other Opening Protectives.

B. Sound Attenuators

1. All tests shall be conducted by a laboratory that is accredited under the National Voluntary Laboratory Accreditation Program (NVLAP) to conduct the test. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted. Where test data is obtained in the manufacturer's laboratory, the facility shall be available for inspection and witnessed testing by the Owner's Representative in order to verify compliance with the latest edition of ASTM Standard E477 or a test standard approved by the Owner's Representative. The Owner's Representative shall be the final arbiter in determining compliance.
2. Manufacturer's Experience: The manufacturer shall have successful experience in duct silencer production, including no less than ten years experience in fabrication and delivery of duct silencers equal in size and quantity to this work. The Manufacturer shall be capable of supplying references and acoustical test results for up to five recently completed projects similar to this work.

3. Acoustical and Aerodynamic Performance: Sound Attenuator acoustical and aerodynamic performance shall be determined in accordance with the latest edition of ASTM Standard E477-90 Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers or a test standard approved by the Owner’s Representative. All silencer ratings shall be determined in a duct-to-reverberant room test facility that provides for airflow in both directions through the test silencer in accordance with the latest edition of ASTM E-477 test standard or a test standard approved by the Owner’s Representative. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

PART 2 PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Provide products by one of the following:

1. Pottorf Air Products.
2. Greenheck.
3. Or equal.

2.4 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Provide products by one of the following:

1. Pottorf Air Products.
2. Greenheck.
3. Or equal.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.063-inch- thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades

1. Multiple, 0.050-inch- thick aluminum sheet.
2. Maximum Width: 6 inches.
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

G. Blade Seals Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets
   1. Material: Galvanized steel.
   2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Bronze.

L. Accessories
   1. Flange on intake.
   2. Adjustment device to permit setting for varying differential static pressures.

2.5 VOLUME DAMPERS

A. Manufacturers: Provide products by one of the following:
   1. Pottorf Air Products.
   2. Nailor Industries Inc.
   3. Or equal.

B. General Description
   1. 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.
   2. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Standard Volume Dampers (3-inch wg and above and / or 12 inches by 12 inches and above): Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
   1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064-inch 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 thick, galvanized sheet steel.
   3. Aluminum Frames: Hat-shaped, 0.10-inch thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
   4. Extruded-Aluminum Blades: 0.0705-inch thick extruded aluminum.
   5. Blade Axles: Galvanized steel.
   6. Bearings: Oil-impregnated bronze.
   7. Tie Bars and Brackets: Galvanized steel.

D. Standard Volume Dampers (2-inch wg and below and / or 12 inches by 12 inches and below): Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
   1. Comply with SMACNA Fig. 2-11B, 2-11D, "Side Elevation Fig. 2-11B" and Text on Volume Dampers" for all details for pressure class 2" W.G. and below on single blade and two bladed damper . Maximum of two blades without a frame
      a. Quadrant shall be Durodyne Model 3/8-inch K-4/1/2" K-5 Quadline; Ventlox Model 555 Ventline; or equal.
      b. Provide closed end bearing on medium pressure ductwork, Durodyne SB-338 (3/8")/SB-312 (1/2"); Ventlox Model 609; or equal.

c. Install each square rod vertical or horizontal so that quadrant shall be accessible for adjusting.
2. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
3. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
4. Aluminum Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
5. Extruded-Aluminum Blades: 0.0575-inch- thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings: Oil-impregnated bronze.
8. Tie Bars and Brackets: Galvanized steel.

E. 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 stainless sheet steel channels, minimum of 0.064 inch 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- thick, galvanized sheet steel.
3. Aluminum Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.0575-inch- thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings: Oil-impregnated bronze thrust or ball.
8. Blade Seals: Felt or Vinyl.
9. Jamb Seals: Cambered stainless steel.
10. Tie Bars and Brackets: Galvanized steel.

F. Jackshaft: 1-inch diameter, galvanized-steel pipe rotating within 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 in multiple-damper assembly.

G. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

A. Manufacturers: Provide products by one of the following:

1. Pottorf Air Products.
2. Nailor Industries Inc.
3. Or equal.

B. Low-leakage rating with linkage outside airstream and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames

1. Hat shaped.
2. 0.094-inch thick galvanized sheet steel.
3. Mitered and welded, interlocking, gusseted corners.

D. Blades

1. Multiple blade with maximum blade width of 6 inches.
2. Parallel, Parallel and opposed, Opposed-blade design.
3. Galvanized steel, Stainless-steel, Aluminum
4. 0.064 thick single skin

5. Blade edging: Closed-cell neoprene.

E. Blade Axles: ½ inch diameter; galvanized steel, stainless steel; blade linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 degree F.

F. Bearings:

1. Oil impregnated bronze, Oil impregnated stainless steel.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers

1. Pottorf Air Products.
2. Nailor Industries Inc.
3. Greenheck.
4. Or equal.

B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.

C. Combination fire and smoke dampers shall be minimum Class 1, 250 degrees F. leakage/temperature rating with maximum leakage of 8 cfm per square foot of damper area at 4 inches W.G.

D. Heat Links: Reusable, 165 degrees F rated to interrupt power to the motor.

E. Frame: 0.064-inch- thick, rigid galvanized sheet steel hat section with integral reinforced corner braces.

F. Coordinate NC level below with Owner’s Representative.

G. Blades: 0.064-inch- thick, rigid galvanized sheet with bronze oilite sleeve type bearings. Provide dampers with airfoil blades at shaft penetrations, in all locations where duct velocity exceeds 1,500 fpm, and in all acoustically critical spaces (NC-30 and lower). Provide dampers with triple V blades in all other locations.

H. Blade edge seals shall be silicone rubber for high temperature resistance. Jamb seals shall be silicone rubber backed flexible stainless steel specifically designed for air pressure assist sealing. Axles shall be minimum 1/2-inch square, plated steel with .125-inch plated steel tiebar linkage, concealed in frame, out of the airstream.

I. Closure spring shall be stainless steel.

J. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application, but minimum 16 inches.

K. Damper Motors: Two-position action.

1. Comply with requirements in Section 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
2. ISO 9000 recognized control manufacturer and certified by ETL laboratories for 1 year continuous power applications. Motor actuators must reopen damper fully regardless of length of power interruption time, provide minimum 5-year damper and actuator warranty.
3. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating according to UL and CSFM listing.
4. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F.
5. Non-spring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating according to UL and CSFM listing.
6. Electrical Connection: 115 V, single phase, 60 Hz.

7. The damper motor shall be specifically listed and approved as fire/smoke damper actuator for the damper to which it is applied. Field installed actuators are not acceptable.

2.8 SEISMIC EXPANSION JOINTS

A. Use flexible duct connectors to connect all ducting at seismic joints.

B. Anchor the duct to the structure. Anchorage details and calculations shall be stamped by a California registered structural engineer and submitted for review to the Owner's Representative.

C. The flexible connector shall be furnished with flanges and soldered to galvanized sheet metal duct or welded to stainless steel duct and shall be 12" long.

2.9 SOUND ATTENUATORS

A. Product: Provide the product indicated on drawings or a product by one of the following:
   1. Vibro-Acoustics.
   2. Pottorf Air Products.
   3. Or equal.

B. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated.

C. Special Construction: Suitable for outdoor use where indicated.

D. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

E. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- thick, solid galvanized sheet metal for outer casing and 0.022-inch- thick, ASTM A 653/A 653M, G90, perforated galvanized sheet metal for inner casing. Seams shall be mastic filled.

F. Round Units
   1. Outer Casings
      a. ASTM A 653/A 653M, G90, galvanized sheet steel.
      b. Up to 24 Inches in Diameter: 0.034-inch thick.
      c. 26 through 40 Inches in Diameter: 0.040-inch thick.
      d. 42 through 52 Inches in Diameter: 0.052-inch thick.
      e. 54 through 60 Inches in Diameter: 0.064-inch thick.
      f. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.
   2. Interior Casing, Partitions, and Baffles
      a. ASTM A 653/A 653M, G90, galvanized sheet steel.
      b. At least 0.034-inch thick and designed for minimum aerodynamic losses.

G. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

H. Fill Material: Inert, moisture and vermin-proof fibrous material, packed under not less than 5 percent compression.
   1. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.

I. Packless Silencers: No sound absorptive material of any kind is to be used in packless type silencers. These silencers shall attenuate air transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.

J. 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, or 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.

K. Source Quality Control
   1. Acoustic Performance: Test according to ASTM E 477.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000 fpm face velocity.
   3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

L. Acoustical and Aerodynamic Performance
   1. Minimum Dynamic Insertion Loss: Laboratory measured octave band dynamic insertion loss values shall meet or exceed any values specified in the Duct Silencer Schedule provided on the mechanical drawings.
   2. Maximum Self-Generated Noise: Laboratory measured octave band self-generated sound power levels shall not exceed any values specified in the Duct Silencer Schedule provided on the mechanical drawings. Self-generated noise values shall be based upon a face area of 4 square feet.
   3. Maximum Pressure Drop: Laboratory measured pressure drop values at rated air volumes shall not exceed values specified in the Duct Silencer Schedule provided on the mechanical drawings.

2.10 REMOTE DAMPER OPERATORS

A. Manufacturers: Provide products by the following:
   1. Young Regulator Company.
   2. Pottorf Air Products.
   3. Or equal.

B. Description: Cable system designed for remote manual damper adjustment.

C. Cable: 0.054 inch Stainless Steel control wire with 0.0625 inch galvanized steel casing.
   1. Distance from controlled volume damper not to exceed 10 feet.

D. Wall-Box Mounting: Recessed.

E. Wall-Box Cover-Plate Material: Steel.
   1. Cover plate shall not exceed 7/8 inch diameter

2.11 TURNING VANES

A. Manufacturers
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. METALAIRE, Inc.
   4. Ward Industries, Inc.
   5. Or equal.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

C. For duct width less than 18” use minimum 0.187-inch thick vanes 2-1/8” O.C. For ducts 18” and wider use minimum 0.0236-inch vanes.

D. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.12 DUCT MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches. Door frames shall not project inside ducts.

1. Manufacturers
   a. Ductmate Industries, Inc.
   b. Greenheck.
   c. Nailor Industries Inc.
   d. Or equal.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows
   a. Less than 12 Inches Square: Secure with two sash locks.
   b. Up to 18 Inches Square: Two hinges and two sash locks.
   c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches. Door frames shall not project inside ducts.
   1. Manufacturers
      a. Ductmate Industries, Inc.
      b. Flexmaster U.S.A., Inc.
      c. Or equal.
   2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain. Door frames shall not project inside ducts.
   1. Manufacturers
      a. Ductmate Industries, Inc.
      b. Greenheck.
      c. McGill AirFlow Corporation.
      d. Or equal.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.13 FLEXIBLE CONNECTORS FOR VIBRATION ISOLATION

A. Refer to Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC.

2.14 FLEXIBLE DUCTS

A. Manufacturers
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.
   3. McGill AirFlow Corporation.
   4. Or equal.

B. Non-insulated-Duct Connectors: UL 181, Class 0, interlocking spiral of aluminum foil.
   1. Pressure Rating: 8-inch wg positive or negative.
   2. Maximum Air Velocity: 5000 fpm.
   3. Temperature Range: Minus 100 to plus 435 degrees F.

C. Insulated-Duct Connectors: UL 181, Class 1, 2-ply porous inner sleeve of spun-bonded non-woven nylon supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 10 to plus 160 degrees F.
   4. Applicable Standards and Test Conditions: Acoustical performance of the acoustical flexible air duct shall be in accordance with Air Diffusion Council Flexible Air Duct Test FD72R1: Paragraph 3.2.1, Sound Attenuation. The test data shall be made by an accredited independent testing laboratory in accordance with the above testing procedure.

5. The sound attenuation (insertion loss) of the acoustical flexible air duct shall meet or exceed the values tabulated below
6. Straight Duct Insertion Loss in Decibels per Length of 10 Feet with No Airflow

Acoustical Flexible Air Duct Inner Diameter	Octave Band Center Frequency (Hz)						
	125	250	500	1000	2000	4000	8000
6 Inches	20	25	30	33	30	25	22
10 Inches	18	20	25	28	25	22	20
16 Inches	15	18	20	25	22	15	15

a. Material: The material shall be CASCO Acoustical Flex Duct SF-181M or equal.

D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

2.15 DRAFT GAUGES

A. Manufacturers: F.W. Dwyer, Chicago, Illinois, non-fluid magnahelic type, Ellison Instrument, or equal.

B. Provide draft gauges across all filter banks to show differential pressure across filters. Mount draft gauges on same panel as provided for remote thermometers, where possible, or on separate panels of the same type. Gauges shall be of the remote type connected to tappings on both sides of the filters and connected to reading points with 1/4 inch copper tubing, shut-off cocks shall be provided on each side of gauge.

2.16 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.

B. For ducts with either dimension in excess of 18 inches fabricate multi-blade, parallel action gravity balanced backdraft dampers of 16 gage stainless steel with blades of maximum 6-inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.17 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized steel ducts, stainless steel accessories in stainless steel ducts and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 – “Shutoff Damper Controls,” restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Backdraft dampers
   1. Install backdraft dampers on outside air intakes, exhaust fans or exhaust ducts nearest to outside and where indicated.
   2. Gravity backdraft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.

E. Volume / Balancing Dampers
   1. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
   2. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff and as far from diffuser, grille or register as possible.
   3. Unless indicated otherwise below or on drawings volume dampers shall be standard design:
      a. Spaces with sound rating NC 30 and below: Low Leakage High Performance
      b. Spaces with tight environmental control (humidity ±10 percent RH or better and / or temperature plus or minus 2 degrees °F or better): Low Leakage High Performance
      c. Duct pressure classification positive or negative 4 inches W.C. or above: Low Leakage High Performance
   4. Utilize aluminum framed and blades for volume dampers in wet air streams, utilize galvanized steel blades and frames in all other locations.
   5. Cut slot in end of volume damper rod (Quadrant End) to indicate blade position.
   6. Provide galvanized sheet metal "hat section" for volume dampers on ducts with exterior insulation so that quadrant will be exposed.
   7. Provide access door for each volume damper that is located above inaccessible ceiling such as gypboard, location to be shown on shop drawings and reviewed by Owner's Representative. Refer to Section 230500 – COMMON WORK RESULTS FOR HVAC.
   8. Use remote volume damper operator for volume dampers located above inaccessible ceiling such as gypboard or where access is limited due to the ceiling space congestion or were shown on plans. Regulator shall be embedded in the finished ceiling or wall material so that the unit shall be flush with the finished ceiling.
   9. Provide volume dampers with red ribbon tags so it can be easily distinguished from ductwork.

F. Install turning vanes in all mitered duct elbows and where shown on the Drawings.

G. Combination Fire Smoke Dampers
   1. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.
   2. Provide smoke fire dampers in all duct openings through all respective fire-rated partitions, walls, floors and roofs unless indicated otherwise.
   3. All combination smoke fire dampers shall be connected to the fire alarm system.
   4. Extend each sleeve for combination fire smoke dampers through the partition or wall far enough on either side for a proper breakaway duct connection in accordance with NFPA and SMACNA recommendations.
   5. Fire dampers shall have a free area equal to the duct to which they are installed. Provide applicable transitions.

H. Sound Attenuators
   1. Install where shown on drawings in accordance with the manufacturer's recommendations to obtain the published acoustical and air flow performance.
   2. Duct Silencer baffles should be oriented so as to be parallel to the plane of the turn if the silencer is located in a position less than 3 duct diameters in distance from the elbow. The duct diameter shall be based upon the maximum duct cross sectional dimension of the sound attenuator.
   3. Do not locate rectangular sound attenuators within one duct diameter from elbows, fan suction or discharge openings, takeoffs, etc.
   4. Support duct silencers independent of ductwork, provide seismic bracing.

I. Duct Access Doors

1. Install airtight duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows, do not obstruct access doors with piping, etc.
    a. On both sides of duct coils.
    b. Downstream from volume dampers, turning vanes, and equipment.
    c. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
    d. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
    e. On sides of ducts where adequate clearance is available.
2. Install the following sizes for duct-mounting, rectangular access doors
    a. One-Hand or Inspection Access: 8 by 5 inches.
    b. Two-Hand Access: 12 by 6 inches.
    c. Head and Hand Access: 18 by 10 inches.
    d. Head and Shoulders Access: 21 by 14 inches.
    e. Body Access: 25 by 14 inches.
    f. Body Plus Ladder Access: 25 by 17 inches.
3. Install the following sizes for duct-mounting, round access doors
    a. One-Hand or Inspection Access: 8 inches in diameter.
    b. Two-Hand Access: 10 inches in diameter.
    c. Head and Hand Access: 12 inches in diameter.
    d. Head and Shoulders Access: 18 inches in diameter.
    e. Body Access: 24 inches in diameter.
4. Install the following sizes for duct-mounting, pressure relief access doors
    a. One-Hand or Inspection Access: 7 inches in diameter.
    b. Two-Hand Access: 10 inches in diameter.
    c. Head and Hand Access: 13 inches in diameter.
    d. Head and Shoulders Access: 19 inches in diameter.
5. Label access doors according to Section 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.

J. Flexible Connectors

1. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
2. Allow at least 1 inch slack in flexible connections to insure that no vibration is transmitted from fan to ductwork
3. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

K. Flexible Duct

1. Connect diffusers or light troffer boots to low pressure ducts with maximum 84-inch lengths of flexible duct clamped or strapped in place.
2. Connect flexible ducts to metal ducts with draw bands.
3. Installation of the acoustical flexible air duct shall be in accordance with the manufacturer's instructions and recommended procedures. Bends shall not have a radius of curvature smaller than 1.5 duct diameters. Before entering the rear of any diffuser, flexible duct must be straight and perpendicular to the diffuser for a minimum of 3 duct diameters.
4. Flexible duct must not be installed directly at the inlet or discharge of any volume control device

L. Duct Test Holes

1. Install duct test holes as required for testing and balancing purposes, cap with threaded metal caps.
2. Provide test holes at all fan inlets and outlets and elsewhere as indicated on drawings and elsewhere in the specifications.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate combination fire and smoke dampers to verify full range of movement and verify that proper heat response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.

END OF SECTION

SECTION 233417
LABORATORY EXHAUST FANS

PART 1 GENERAL

1.1 REFERENCE

A.	AMCA 99	Standard Handbook
B.	AMCA 210	Laboratory Method of Testing Fans for Rating Purposes
C.	AMCA 211	Certified Ratings Procedure
D.	AMCA 300	Test Code for Sound Rating Air Moving Devices
E.	AMCA 311	Certified Sound Rating Program for Air Moving Devices
F.	AMCA 204	Balance Quality and Vibration Levels of Fans
G.	AMCA 500	Test Methods for Louvers, Dampers and Shutters
H.	AFMBA	Method of Evaluating Load Ratings of Bearings
I.	SMACNA	Medium Pressure Plenum Construction Standards
J.	ANSI Z9.5	Laboratory Design
K.	ASHRAE	Laboratory Design Guide

1.2 RELATED SECTIONS

A. See Commissioning Requirements Section 019113.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.3 QUALITY ASSURANCE

A. Performance ratings: Conform to AMCA standard 210, 260 and 300 fans. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210), sound performance (AMCA 300) and induced flow fan for high plume diution blowers (AMCA 260).

B. Classification for Spark Resistance construction shall conform to AMCA 99.

C. Fans shall be UL and CUL listed per UL 705 safety standard.

D. Fans shall meet the criteria of NFPA-45.

E. All fans prior to shipment shall be completely assembled and test run as a unit at the specified operating speed or maximum RPM allowed for the particular construction type. Each wheel shall be statistically and dynamically balanced in accordance with ANSI/AMCA 204 “Balance Quality and Vibration Levels for Fans” to Fan Application Category BV-3. Balance Quality Grade G6.3. Balance readings shall be taken by electronic type equipment in axial, vertical, and horizontal directions. Records shall be maintained and a written copy shall be available upon request.

1.4 SUBMITTALS

A. Submit shop drawings and product data sheets including performance data, fan performance curves, vibration levels, maintenance requirements and sound power levels.

B. Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, acoustical silencer nozzle, stack extension if any, and all related accessories specified herein have been pre-tested at the factory and that the curves supplied in 1.3.1 have been de-rated for any and all system effects created by the accessories.

C. Provide dimensional drawings and product data on each high plume dilution laboratory exhaust fan assembly.

D. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.

E. Provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume height at specified wind velocity.

F. LEED Submittal

1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 WARRANTY

A. Fan manufacturer shall provide a 7 year parts warranty from time of purchase to include fan, plenum, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts. This warranty shall be held solely by the fan manufacturer. It is unacceptable to extend the warranty of a provided component supplier (i.e. motors, dampers, actuators). All warranty claims shall be the sole responsibility of the fan manufacturer.

PART 2 PRODUCTS

2.1 GENERAL

A. Manufacturer: Strobic Air or equal.

B. Base fan performance at standard conditions (density 0.075 lb/ft3).

C. Each fan shall be direct drive in AMCA arrangement 4 according to the drawings.

D. Fans to be equipped with 316 stainless steel lifting lugs for construction resistance.

E. Fasteners exposed to corrosive exhaust shall be stainless steel.

F. Curb Cap shall be hot rolled steel coated with corrosion resistant coating.

G. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment is not acceptable.

H. Fan assembly shall be designed for a minimum of 125 mph wind loading, without use of guy wires.

I. Fans shall have been tested under AMCA 210-85, “Laboratory Methods of Testing Fans for Rating”, or British Standard 848, Part I, “Methods of Testing Performance,” 1980, and shall have been witnessed by an independent agency.

J. Documented aspiration tests shall have been performed in conjunction with the fan performance test. Test shall incorporate AMCA 210 testing standards and physically measure the air volume entering and exiting the fan. This test can be used as an alternative to AMCA 260 testing and shall have been witnessed by an independent agency.

2.2 MIXED FLOW INDUCED DILUTION FANS

A. Impellers shall be mounted directly to the motor shaft to provide a direct drive arrangement #4 type fan. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service. Models that are not arrangement #4 will be rejected.

B. Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading performance characteristics with aerodynamically stable operation at any point on the fan curves. The use of centrifugal or axial style fans is not acceptable.

C. Fan performance shall be as stated on the schedule. The static pressure stated on the schedule shall be at the inlet to the “fan system” and does not include any losses of equipment provided by the fan manufacturer (i.e. HRU, filters, silencers, etc.). All losses for the equipment provided by the fan manufacturer shall be detailed in the fan manufacturer’s technical proposal and or submittal.

D. Fan and drive components shall have a combined bearing life of a minimum of L10 = 150,000 hours.

E. Maintenance shall only be required on a minimum of 18 month intervals. This maintenance shall be limited to re-greasing of the motor bearings.

F. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.

G. Fan dynamic balance not to exceed 0.5 mil, peak-to-peak for nominal 900 rpm, 1200 rpm and 1800 rpm fans, or 0.055 in/sec-peak for 1800 rpm, 0.035 in/sec-peak for 1200 rpm and 0.030 in/sec-peak for 900 rpm fans measured at the blade pass area when operating at fan frequency. Vibration isolation shall be limited to rubber in shear pad type isolators unless otherwise specified.

H. Factory test reports detailing vibration levels at the blade pass area shall be provided. Vibration levels shall be reported in both the axial and radial direction. If fan vibration is greater than 0.5 mils peak-to-peak at the blade pass area, fan manufacturer shall be responsible for providing vibration isolators on each fan and flexible connection at each duct inlet. Manufacturer shall add 0.5" additional static pressure to the fan system to compensate for losses through the flexible connection. Vibration isolators, 2” deflection seismic rated spring, must be installed on each individual fan with a minimum of four per fan. In addition, fan manufacturer shall be responsible for providing a method to repair or replace flexible connection or vibration isolators without shut down of the fan system. This includes any engineering, additional ductwork, and isolation dampers required to perform repairs while the system is still fully operational. Fan manufacturer shall also provide labor to change out or repair flexible connection and vibration isolators for a seven (7) year period from shipment.

I. Fan assemblies shall be designed for mounting on conventional roof curb without the need for guy wire supports.

J. Discharges shall include twin FRP nozzles with passive third central stacks that are capable of generating aspiration. The FRP shall be chemically and UV resistant.

K. Entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Windbands shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.

L. Fan shall be constructed to AMCA “C” standards per AMCA 99 with a non-ferrous inlet bell provided in order to reduce sparking in the event of a motor bearing failure.

M. Fans shall be modular construction and capable of being assembled on the roof.

N. Chemical resistant gaskets shall be provided at all companion flanged joints.

O. Fasteners shall be 316 stainless steel.

P. A bolted access door shall be provided for impeller inspection on each fan.

Q. Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system.

R. Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L10 bearing life of 150,000 hours. Premium Efficient motors shall have regreasable bearings with grease relief fittings in every NEMA frame. Fan motors shall be C-Face and foot mounted.

S. Extended motor lube lines of Teflon tubing covered with braided stainless steel shall be provided. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line.

T. A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor.

U. All steel and aluminum surfaces components within the airstream that are not stainless steel or fiberglass must be surface prepped by abrasive blast clean to SSPC-SP10. Chemically cleaning of these components as a form of surface preparation is not acceptable. These components must be coated with a high solids epoxy with low VOC chemical resistant barrier coating epoxy. The coating system, a total thickness of up to 12 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 7000 hour ASTM B117 Salt Spray Resistance. Standard finish color to be gray. All coatings that include a zinc rich epoxy primer are strictly prohibited. Zinc coatings react with alkalis and acids, thus causing premature failure of the coating system and should never be used for laboratory applications.

V. The fan supplied must meet the system exhaust CFM and the motor BHP shall not be larger than that shown on the fan schedule.

W. Fan and Mixing Box systems supplied by the manufacturer must have a foot print equal or less than as shown on the drawings / schedule. The resizing of the structural pad and the expense for the structural load verification shall be the responsibility of the fan manufacturer.

X. The static pressure shown on the schedule is based on the static pressure requirements at the inlet to the mixing box. Any system deviating from the basis of design shall include and detail in their proposal additional losses for flexible connectors, fan losses, elbows, mixing box, etc. that are not included in their fan curves. In addition any deviation from the basis of design shall be subject to requirements stated in sections 1.4.B, 2.2.H and 2.2.V.

2.3 ACCESSORIES

A. Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirement of the number of fans listed on the schedule. Multiple fan plenums shall be insulated double wall construction with structural stiffeners. Double wall plenums, except for fans over 3hp shall have an overall minimum wall thickness of 1.5”, and the insulation shall have a minimum R value of 4.34. Outer skin of double wall plenums shall be coated 12Ga Galvaneal steel. Inner skin shall be uncoated 18Ga 304 stainless steel. Multiple fan plenums shall be able to withstand a minimum of 12 in. w.g. of negative pressure. Single fan plenums shall be of continuously welded, heavy gauge steel construction. For single thickness plenums, coatings shall be the same as specified for the fans. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors. The primary air inlets shall be located on the bottom or side as noted on construction drawings. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs. Safety screens shall be supplied over inlet of fan.

B. Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Bypass damper(s) shall be sized to bypass the airflow capacity of one fan at the required static pressure of the system. Dampers will be opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. Rain hoods shall be provided with each damper. The dampers shall be controlled by a 24v electric proportional control damper actuators shall be electronic direct-coupled type, which require no crankarm and linkage. Actuators must provide proportional damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. Actuators shall have Brushless DC motor technology and be protected from overload at all angles of rotation. Actuators shall have reversing switch and manual override on the cover. Run time shall be constant and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position indication.

C. An acoustic louver shall be provided at the inlet to the bypass dampers on systems requiring sound attenuation.

D. Low leakage isolation dampers shall be constructed of aluminum air foil extrusions and epoxy coated. Operators shall be 2 position, spring return and shall have On-off spring return damper actuators that are direct coupled type which require no crankarm and linkage and be capable of direct mounting to a jackshaft. The actuators must be designed so that they may be used for either clockwise or counterclockwise fail-safe operation. Actuators shall have a manual positioning mechanism accessible on its cover. Actuators shall use a brushless DC motor and be protected from overload at all angles of rotation. Run time shall be constant and independent of torque. Auxiliary switches, 2 SPDT, shall be provided with one switch having the capability of being adjustable.

E. Vortex breakers shall be provided on all side inlet and multiple fan plenums.

F. A galvanized steel roof curb shall be provided to support the fans/plenums. The curb shall be minimum 14 gauge and canted for rigidity in wind loads. The curb shall include a rigid fiberglass liner and a wood nailer.

G. Acoustical Silencer Nozzle shall be designed as an integral component of the exhaust fan discharge nozzle and shall not increase the height of the overall assembly. Integral Acoustical Silencer Nozzle with a minimum of 12dBA insertion loss. Lining the interior of the windband is not an acceptable method of attenuation due to line of site sound in the free area between the nozzle and windband.

1. The Acoustical Silencer Nozzle shall provide the attenuation values as specified in the following schedule. The published insertion loss values shall be obtained from an AMCA 300 test with the silencer installed on the fan specified. Ratings based on separate silencer and fan testing is not acceptable.

OCTAVE BAND CENTER FREQUENCY (Hz)									
FAN SIZE / SILENCER MODEL	LENGTH	63	125	250	500	1000	2000	4000	8000
TS-2	64"	0	4	9	11	12	13	9	4
TS-3	88"	0	6	7	10	11	7	11	2
TS-4	89"	5	8	9	11	12	12	10	6
TS-5	93"	3	14	15	17	18	13	8	6

2. The silencer shall be constructed with an outer shell of fiber reinforced plastic. The inner liner shall be perforated corrosion resistant steel. The silencer shall match the color of the fans. Acoustic media shall be isolated from the air stream by a non fibrous acoustical media.

H. Provide a jib crane socket for each fan to be used for mounting jib crane during fan component removal.

I. Provide 1 jib crane with two position telescoping extension boom. Crane to support up to 2-ton capacity, rotates 360 degrees with 4 position lock. Crane shall be able to fold into compact arrangement while not in use.

2.4 LAB EXHAUST FAN CONTROL

A. The laboratory exhaust fan manufacturer shall supply an electronic control system to monitor and control the operation of the laboratory exhaust fans.

B. The control package shall be capable of maintaining the laboratory exhaust system static pressure at predetermined level regardless of laboratory activity (i.e. opening/closing of laboratory hoods). This shall be accomplished without any user input.

C. The outlet velocity of each fan in the exhaust system shall be maintained at a minimum of 3,000 fpm at all times.

D. The static pressure at which the system is required to be maintained shall be capable of being set manually at the control package interface. The control package shall also be capable of receiving the static pressure set point from the building control system.

E. Fans running simultaneously shall run at the same speed.

F. The control package shall stage the fans in the system so that no one fan is idle for more than 39 days.

G. The control package shall respond to a failure of one fan by energizing an unused fan to replace it.

H. A communication card shall be included which will allow information to be sent from the control package to the building control system. This information shall include the measure system static pressure, the frequency at which the VFDs are running, the power consumption of each fan and fault status.

I. Wiring shall be done in the factory so as to minimize field wiring. Control wiring shall be brought to a single point in both the rooftop exhaust unit and VFD equipment and shall be connected in the field with a single conduit run.

J. The control shall be powered separately from any other component in the system.

K. The control package to include energy saving mode, to reduce the quantity of fans in operation and minimize outside bypass air requirement, therefore reducing energy consumption.

2.5 VARIABLE FREQUENCY DRIVES

A. General: Furnish complete individual variable frequency VFDs for each fan designated on the drawing schedules to be variable speed with requirements in Section 262923 VARIABLE FREQUENCY MOTOR CONTROLLERS.

B. Install VFD recessed in the unit or in a panel if mounted on the fan casing to avoid LCD screen from fading.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install fans as indicated on the contract drawings.

B. Pipe housing drain to the nearest roof drain.

C. Fan or Fan/Plenum assembly shall be mounted on a structural curb with a specified height as shown on the drawings. Roof curb shall be insulated and fabricated of a minimum 14 Ga. structurally reinforced galvanized steel.

D. Vibration isolation shall be limited to neoprene vibration pads.

E. Install fans in accordance with manufacturer’s instruction, applicable specification and code requirements.

F. Install units with clearances for service and maintenance.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and those connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system.
   5. Adjust damper linkages for proper damper operation.
   6. Verify lubrication for bearings and other moving parts.
   7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   8. Disable automatic temperature control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, measure and record motor voltage and amperage.
   9. Shut unit down and reconnect automatic temperature control operators.

10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipments.

END OF SECTION

SECTION 233423
HVAC POWER VENTILATORS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. In-line centrifugal fans.
   2. Centrifugal roof ventilators.

B. Related Sections
   1. See Commissioning Requirements Section 019113.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations above sea level.

B. Selected fans shall be capable of accommodating static pressure and flow variations of plus or minus 15 percent of scheduled values.

C. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Fan speed controllers.
   7. Manufacturer’s certificate: Certify products meet or exceed specified requirements.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

1.4 FIELD QUALITY-CONTROL TEST REPORTS.

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

B. LEED Submittal

1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Owner's Representative, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

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

1.8 EXTRA MATERIALS

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

1. Belts: Two sets for each belt-driven unit.
2. Sheaves: One extra set of fixed sheaves.

1.9 WARRANTY

A. Manufacturer agrees to repair or replace equipment/device/component that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Greenheck.
2. Loren Cook Company.

3. Penn Ventilation.
1. Or equal.

B. Description: In-line, direct-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Driven Units: Motor mounted outside airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.

G. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum L10 life in excess of 200,000 hours at maximum catalogued operating speed.

H. Drives shall be sized for a minimum of 150 percent of driven horsepower.

I. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

J. Motor pulleys shall be adjustable for final system balancing. A NEMA 1 disconnect switch shall be provided as standard. Factory wiring shall be provided from motor to the handy box.

K. All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.

L. Each fan shall bear a permanently affixed manufacturer’s nameplate containing the model number and individual serial number for future identification.

M. Accessories
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   3. Companion Flanges: For inlet and outlet duct connections.
   4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Greenheck.
   2. Loren Cook Company.
   3. Or equal.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain drains.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

2.3 MATERIAL HANDLING RADIAL BELT DRIVE BLOWERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Greenheck.
   2. Loren Cook Company.
   3. Or equal.

B. Housing:
   1. Process or material handling fans shall be of the heavy duty type with the inlet diameters and outlet areas manufactured in accordance with the standards adopted by AMCA for industrial fans.
   2. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence
   3. The housings on all fan sizes shall be of continuously welded heavy gauge steel. All interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts will be allowed.
   4. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings
   5. Either an OSHA compliant weatherhood, or a combination of an OSHA compliant belt guard and shaft guard shall be included to completely cover the motor pulley and belt(s)

C. Fan Wheels:
   1. The fan wheel shall be of the radial type. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
   2. Fan wheel shall be manufactured with continuously welded steel blades and coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be industrial gray.
   3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Accessories:
   1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

E. Fan Motors and Drive:
   1. Drive belts and sheaves shall be sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service.
   2. Fan shaft to be turned and polished steel that is sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
   3. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty grease lubricated, self-aligning or roller pillow block type.
   4. Air Handling Quality bearings to be designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block. Bearings shall be 100% tested for noise and vibration by the manufacturer. Bearings shall be 100% tested to insure the inner race diameter is within tolerance to prevent vibration.

2.4 MOTORS

A. Comply with requirements in Section 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.6 VARIABLE FREQUENCY DRIVES

A. General: Furnish complete individual variable frequency VFDs for each fan designated on the drawing schedules to be variable speed with requirements in Section 262923 VARIABLE FREQUENCY MOTOR CONTROLLERS.

B. Install VFD in a panel to avoid LCD screen from fading.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware.

C. Support suspended units from structure using threaded steel rods and vibration isolators having a static deflection as shown on the contract drawings. Vibration-control devices are specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

D. Install fans with clearances for service and maintenance.

E. Label fans according to requirements specified in Section 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.

F. All exhaust and outside air equipment shall incorporate dampers that automatically close during periods of non-use. The dampers shall be either motorized or gravity type.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 – AIR DUCT ACCESSORIES.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

D. Install flexible connections between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

E. Install fan restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating.

F. Install fans with flexible electrical leads.

G. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

H. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Refer to Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC for testing, adjusting, and balancing procedures
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

SECTION 233600
AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Shutoff single-duct air terminal units.
   2. Series, fan powered terminal units.
   3. Exhaust single duct terminal units.

B. Related Sections
   1. See Commissioning Requirements Section 019113.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. LEED Submittal
   1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

D. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   1. Wiring Diagrams: Power, signal, and control wiring.

E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

F. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 – Operation and Maintenance Data include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software setpoints.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Section 016000 – MATERIALS AND EQUIPMENT.

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

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.4 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers

1. Price Industries.
2. Titus.
3. Or equal.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 22 gauge steel.

1. Casing Lining: Standard unit: Adhesive attached, 3/4-inch thick, hospital grade foil faced acoustical duct liner/insulation, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

F. Attenuator Section: 22 gauge steel, minimum 3 feet long.

1. Lining: to match casing lining.

G. Multi-outlet Attenuator Section: With size and number of outlets indicated on the drawings. Outlets shall have collars; each with locking butterfly balancing damper.

H. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed. Provide number of rows per plans.

I. Disconnect switch - Provide single duct terminals with a factory installed and wired switch to disconnect power to the unit controls.

J. Controls Transformer - Provide factory installed and wired 24 VAC transformer to provide control voltage power to the unit.

K. DDC Controls: Single-package unitary controller including damper motor, transducer, transformer and actuator specified in Section 230923 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC shall be supplied by the Controls contractor and furnished to the terminal unit supplier for mounting in the factory. Field mounted DDC controls are not acceptable.

L. Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Section 230923 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC and shall have the following features
   1. Damper Actuator: 24 V, powered closed, powered open.
   2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
      a. Proportional, plus integral control of room temperature.
      b. Time-proportional reheat-coil control.
      c. Occupied and unoccupied operating mode.
      d. Remote reset of airflow or temperature set points.
      e. Adjusting and monitoring with portable terminal.
      f. Communication with temperature-control system specified in Section 230923 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

M. Thermostats and Sensors: Communication with temperature-control system specified in Section 230923 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

2.3 MAXIMUM SOUND POWER LEVELS OF HVAC TERMINAL UNITS

A. Scope: Terminal units shall be tested to, and comply with, all requirements of this specification. Representative samples shall be subjected to tests in accordance with applicable standards and procedures in order to demonstrate such compliance. A special test for this project is not required if the manufacturer has previous certified test results that can be made applicable to this Project.

B. Test Conditions and Applicable Standards: All sound power level measurements and calculations shall be made in complete accordance with the latest version of ARI Standard 880. Equivalent test and calculation procedures may be substituted for the above procedures if approved in advance by the Owner’s Representative.

C. The results of the test shall be certified by the independent testing agency or an ARI-approved testing laboratory and submitted to the Owner’s Representative for review. The submittal shall include a complete description of the test conditions, methods and procedures.

D. The sound power levels (PWLs) re 10-12 Watts of casing and discharge noise of the unit shall not exceed those listed in the following schedule when operating at the maximum design airflow and static pressure conditions. In the event the equipment produces pure tone components, sound power levels in the relevant frequency bands must be 5 decibels lower than those listed below.

Service (Ducted) or Location (Radiated)	Acoustical Performance for Terminal Units											
	Maximum Allowable Discharge Sound Power Level (dB re 10^{-12}W)						Maximum Allowable Radiated Sound Power Level (dB re 10^{-12}W)					
	Octave Band Center Frequency						Octave Band Center Frequency					
	125	250	500	1k	2k	4k	125	250	500	1k	2k	4k
NC-30 AREAS	61	58	57	57	55	50	54	50	47	46	44	43
NC-35 AREAS	65	62	62	62	60	55	59	55	52	51	49	48
NC-40 AREAS	70	67	67	67	65	60	64	60	57	56	54	53
NC-45 AREAS	73	71	71	72	70	65	67	64	61	61	59	58
	Notes: Provide a minimum of 5 feet of acoustical flexible duct at the connection to each diffuser, unless shown otherwise.											

2.4 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install air terminal unit's level and plumb. Maintain sufficient clearance for normal service and maintenance.

B. All cut edges of insulation shall completely coated with NFPA 90A approved sealant to prevent entrainment of fibers in the air stream. Complete metal edge insulation enclosure is also acceptable.

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 air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Section 232113 – HYDRONIC 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.

D. Connect ducts to air terminal units according to Section 233113 – METAL DUCTS.

E. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

F. 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.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. To assure proper operation and control, the contractor shall recalibrate the transducers six (6) months after acceptance of the Control system to correct any deviations as a result of transducer drift.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Section 017900 – DEMONSTRATION AND TRAINING.

END OF SECTION

SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Rectangular and square ceiling diffusers.
   2. Linear slot diffusers.
   3. Adjustable bar registers and grilles.
   4. Fixed face grilles.
   5. Linear Diffusers.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

C. Related Sections
   1. Section 089000 – LOUVERS AND VENTS, for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
   2. Section 233300 – AIR DUCT ACCESSORIES, for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

B. Source quality-control reports.

PART 2 PRODUCTS

2.1 CEILING DIFFUSERS

A. Square Plaque Ceiling Supply/Return Air Diffusers
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
      a. Price Industries.
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Devices shall be specifically designed for variable-air-volume flows.
   3. Material: Steel.
   4. Finish: Baked enamel, color selected by Owner's Representative.
   5. Face Size: Refer to Schedules.
   6. Face Style: Plaque.
   7. Mounting: Surface or T-bar.
   8. Pattern: Non-adjustable.
   9. Dampers: None.

B. Square Modular Core Perforated Ceiling Supply Air Diffusers
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
      a. Price Industries.
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Devices shall be specifically designed for variable-air-volume flows.
   3. Material: Steel.
   4. Finish: Baked enamel, color selected by Owner's Representative.
   5. Face Size: Refer to Schedules.
   6. Face Style: Perforated.
   7. Mounting: Surface or T-bar.
   8. Pattern: Adjustable.
   9. Dampers: None.

C. Square Perforated Ceiling Return Air Diffusers (Ducted Return)
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
      a. Price Industries PDDR (Ducted Return).
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Devices shall be specifically designed for variable-air-volume flows.
   3. Material: Steel.
   4. Finish: Baked enamel, color selected by Owner's Representative.
   5. Face Size: Refer to Schedules.
   6. Face Style: Perforated.
   7. Mounting: Surface or T-bar.
   8. Pattern: Not Applicable.
   9. Dampers: None.

D. Square Perforated Ceiling Return Air Diffusers (Plenum Return)
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
      a. Price Industries PDDR (Plenum Return).
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Material: Steel.

3. Finish: Baked enamel, color selected by Owner’s Representative.
4. Face Size: Refer to Schedules.
5. Face Style: Perforated.
6. Mounting: Surface or T-bar.
7. Pattern: Not Applicable.
8. Dampers: None.

2.2 REGISTERS AND GRILLES

A. Adjustable Bar Register
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Price Industries.
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Material: Steel.
   3. Finish: Color selected by Owner’s Representative.
   4. Face Blade Arrangement: Horizontal spaced 3/4-inch apart.
   5. Core Construction: Integral.
   6. Frame: 1-1/4 inches wide.
   7. Mounting: Refer to schedules.
   8. Damper Type: Adjustable opposed blade where shown.
   9. Accessories
      a. Front-blade gang operator.

B. Fixed Face Register
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Price Industries.
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Material: Steel.
   3. Finish: Baked enamel, Color selected by the Owner’s Representative.
   4. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core.
   5. Core Construction: Removable.
   6. Frame: 1 inch wide.
   7. Mounting: Refer to schedules.
   8. Damper Type: None

2.3 LAMINAR DIFFUSERS

A. Laminar Ceiling Diffusers
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Price Industries.
      b. Titus.
      c. Nailor Industries Inc.
      d. Or equal.
   2. Devices shall be specifically designed for variable-air-volume flows.
   3. Material: Steel.
   4. Finish: Color selected by Owner’s Representative.
   5. Face Size: Refer to Schedules.
   6. Face Style: Perforated.
   7. Mounting: Refer to schedules.
   8. Pattern: Non-adjustable.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Owner’s Representative for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 234100
PARTICULATE AIR FILTRATION

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. MERV: Minimum Efficiency Rating Value – ASHRAE 52.2.

C. Efficiency: Atmospheric Dust Spot – ASHRAE 52.1.

1.3 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.
   1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   3. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Section 01 60 00 – Materials and Equipment.

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

C. Comply with ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 90A and NFPA 90B.

F. All filter material to conform to Class I of California Code of Regulations (CCR) Title 19.80.03.

G. Filters shall comply with California Code of Regulations T-19.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Provide one complete set of filters for each filter bank.
   2. Provide one container of red oil for inclined manometer filter gage.

B. Provide one set for each unit for construction, provide one set of filters for test and balance replace filters with one set of new filters prior to building handover.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   1. Air Filters, Adsorbers, Containment Units Bag-In/Bag-Out, and Filter-Holding Systems
      a. Flanders Filters, Inc.
      b. Camfil Farr.
      c. American Air Filter
      d. Or equal.
   2. Filter Gages
      a. Dwyer Instruments, Inc
      b. Airguard Industries, Inc.
      c. Or equal.

2.2 EXTENDED-SURFACE, DISPOSABLE PANEL FILTERS

A. Description: Factory-fabricated, dry, extended-surface filters with holding frames. Filters shall be 4-inch thick. The effective filter area shall be no less than 4 to 6 square foot media for each square foot of filter face area.

B. Media: Fibrous material formed into deep-V-shaped pleats with anti-microbial agent and held by self-supporting wire grid, having an average efficiency of 60 to 65 percent.

C. Media and Media-Grid Frame: Heavy duty non-flammable beverage board having diagonal support members bonded to both sides of pleats. Bond the inside periphery of the frame to the filter pack.

D. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, and suitable for bolting together into built-up filter banks.

2.3 85% EFFICIENCY – MERV 13 CATEGORIES FILTERS

A. Air filters shall be high efficiency extended area pleat, totally rigid and disposable type. Filter shall be of the quantities and sizes as indicated on the drawings.

B. Air filters shall have an average efficiency of not less than 85% when tested in accordance with ASHRAE 52.1 test standard, MERV 13 category 52.2 ASHRAE test standard.

C. Air filters shall contain not less than 21 pleats per lineal foot. Pleats shall incorporate an infinite number of convoluted embossments that effect an irregular and magnified loading surface area for various particulates including lint and fibrous materials.

D. The design of the convoluted pleats shall result in an open entering and exiting free area of not less that 70% thus precluding the possibility of bridging of pleats.

E. The filter media shall be 100% synthetic continuous strand, thermally bonded, and reflexive. Uniformity of pleat alignment will be maintained by the applications of foam melt.

F. The 4-inch pack shall be capable of reflexing to original form without damage to media or structure when subjected to unit force pressure of 70 lbs. per square foot of face area.

G. The 4-inch pack shall be assembled and encased into a high impact polystyrene frame. The periphery of the media pack shall be bonded to the enclosing frame by the application of Hot-Melt potting.

H. Performance of the filter shall comply with the following minimum performance data based on a 24x24x4 filter tested at 2000 CFM per ASHRAE 52.1 – 52.2:

Type	Initial Resistance at 2,000 CFM	Efficiency	MERV Rating
85	0.48	85%	13

I. Filters shall be listed by Underwriters Laboratories as Class 2.

2.4 12" DEEP, 85% EFFICIENCY - MERV 13 CATEGORIES FILTERS

A. Air filters shall be high-efficiency mini pleat wedge disposable type assembled in a compact and secure enclosing frame.

B. The filter media shall have a minimum efficiency reporting value of MERV 13 when evaluated under the guidelines of ASHRAE Standard 52.2. It shall have an average atmospheric dust spot efficiency of 85 on ASHRAE Test Standard 52.1. Media shall incorporate mechanical particle capture principles and not rely on passive electrostatic charge to achieve minimum efficiency requirements.

C. Filter media shall be microfine glass (water laid) formed into uniformly spaced pleats separated and formed into a minipleat pack design. Media area shall not be less then 193 square feet per 24x24x12 filter.

D. The media packs shall be bonded to the inside periphery of the enclosing frame with polyurethane potting.

E. The enclosing frame shall include galvanized steel channels bonded to the media pack to prevent air bypass and high impact polystyrene top and bottom panels.

F. Performance of the filter shall be as follows based on a 24"x24"x12" unit tested at 2,000 CFM.

	Initial Resistance at 2,000 CFM	Efficiency	MERV Rating	Dust Holding Capacity to 1.50" W.G.
FP-85-24	0.30	85%	13	550 Grams

2.5 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches.
2. Range: 0- to 3.0-inch wg.

B. Manometer-Type Filter Gage: Molded plastic with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

G. Electrical wiring and connections are specified in Division 26 Sections.

H. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

I. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

J. Do not operate fan system until filters (temporary) are in place. Replace temporary filters used during construction.

K. After completion of work and as directed by the Architect and before final testing and balancing of the air handling systems, provide the specified permanent filters.

3.2 TEMPORARY FILTERS

A. Provide one set for each unit of filters for construction, provide one set of filters for test and balance replace filters with one set of new filters prior to building handover.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION

SECTION 235100
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Listed Special gas vents.
   2. Field-fabricated metal breechings and chimneys.

B. Related Sections include the following:
   1. Section 235113 – Draft Control Devices for induced draft and mechanical fans and for motorized and barometric dampers.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Special gas vents.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
   2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT, include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

C. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1 / D1.1M, "Structural Welding Code – Steel," for hangers and supports and AWS D9.1 / D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 – ROOF ACCESSORIES.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: **10** years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

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

1. Security Chimneys Type SSD Secure-Seal
2. Heat-Fab-Fab, Inc. Type CI-Plus
3. Selkirk Inc.
4. Or equal.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 degrees F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1 -inch airspace.

D. Joint method will be male/female overlapping utilizing Viton O-Ring seal for joint seal. Use of Silicon as a joint gasket is prohibited.

E. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

F. Outer Jacket: 440 series Stainless steel.

G. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.2 GUYING AND BRACING MATERIALS

A. Cable: Three galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4-inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16-inch.
3. For ID Sizes 18 to 24 Inches: 3/8-inch.

B. Pipe: Three galvanized steel, NPS 1-1/4.

C. Angle Iron: Three galvanized steel, 2 by 2 by 0.25-inch.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances; water heaters and boilers.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

C. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

D. Lap joints in direction of flow.

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.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION

SECTION 235105
CHIMNEY AUTOMATION SYSTEM

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install a packaged Chimney Automation System and related equipment as shown on the drawings and as specified, complete, including the following:
   1. Packaged ETL listed chimney fan/control combination, listed to UL 378, Standard for Draft Equipment as a complete system.
   2. Electrical connections.
   3. Stack connection.

1.2 RELATED SECTIONS

A. See Commissioning Requirements Section 019113.

1.3 CODES AND STANDARDS

A. In addition to Section 230000, BASIC MECHANICAL REQUIREMENTS, the following published specifications, standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this Section:
   1. UL – Underwriters Laboratories
   2. National Electrical Code

1.4 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture and shall be of a standard catalog product.

B. Draft system guaranteed to operate satisfactory and efficiently without objectionable smoke or odor.

C. Scheduled equipment performance is minimum capacity required.

D. Scheduled electrical capacity shall be considered as maximum available.

E. Equipment to be manufactured at ISO 9001 certified plant.

1.5 SUBMITTALS

A. System vendor shall coordinate equipment product data submittal sheets and shall provide a comprehensive set of interfaced drawings which shall serve as the basis for system evaluation by consulting engineer.

B. Submit the following to the Owner's Representative.
   1. Comprehensive set of mechanical venting calculations based on the Chimney Design Equation published in the ASHRAE Handbook. Calculations must show flue gas volumes, pressure losses, fluctuations in natural draft at different loads and seasonal temperatures as well as estimated temperatures in each venting section to assure compliance with fan temperature rating and detect potential condensation issues. The total draft range must be documented by mechanical venting calculations based on the actual ASHRAE degree range for the geographical location of the installation. The calculations must show the draft over the entire firing range at low, medium and high design temperatures.
   2. Power venter descriptive literature, dimensional diagram and electrical diagram.
   3. Control descriptive literature, dimensional diagrams and electrical diagrams.
   4. Specification review with respect to submitted equipment identifying all areas of compliance and exceptions.
   5. Certification of listing by nationally recognized testing laboratory.

C. Manufacturers not named in these specifications, but those that have received prior approval by the consulting engineer as required within 10 days prior to bid date, shall be permitted one opportunity to receive formal submittal approval. If this approval is not granted by the consulting engineer, the contractor shall submit on the manufacturer name in these specifications only or the contractor will be charged for the submittal review time for alternate manufacturers.

D. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.6 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture and shall be of a standard catalog product.

B. Mechanical draft system guaranteed to operate satisfactory and efficiently and to provide a constant draft that does not fluctuate more than +/- 0.01” W.C. under stable load conditions.

C. Scheduled equipment performance is minimum capacity required.

D. Scheduled electrical capacity shall be considered as maximum available.

E. Equipment to be manufactured at ISO 9001 certified plant.

1.7 OPERATING AND MAINTENANCE MANUALS

A. Provide to Owner’s Representative complete Operation and Maintenance manuals with product literature on the chimney fan and controls, dimensional and wiring diagrams.

1.8 MANUFACTURERS’ WARRANTY

A. All equipment is to be guaranteed against defects in materials and / or workmanship for a period of 2 years from date of substantial completion. The warranty shall be provided by the equipment vendor and shall include the parts necessary to repair or replace all defective parts and materials.

B. The chimney fan is covered by a 10-year warranty against corrosion perforation.

PART 2 PRODUCTS

2.1 MANUFACTURERS, CHIMNEY AUTOMATION SYSTEMS

A. Furnish ENERVEX Chimney Automation System with design volume and design pressure as scheduled on the drawings or equal. The entire system must conform to UL378, Standard for Draft Equipment and bear a certification mark from ETL or other nationally recognized testing laboratory.

B. Alternate manufacturers complying with plans and specifications must be submitted and approved by the consulting engineer within 10 days prior to bid date.

2.2 CHIMNEY AUTOMATION SYSTEM DESIGN

A. The power venter design shall be of a true inline design with intake and exhaust centered on a horizontal axis. It shall be a Type B, Spark Resistant Construction in compliance with AMCA Standard 99-0401. The power venter housing shall be type 316L stainless steel with a minimum thickness of 0.063”. The power venter shall be of the direct drive design and rated for use with temperatures up to 660°F (350°C). The drive unit consisting of the impeller and the motor shall be removable from the housing without having to remove the entire fan from the chimney system. The power venter must be listed for use with all types of heating appliances and this shall be acknowledged in the installation manual.

B. The backward inclined impeller shall be made in non-ferrous material to eliminate the possibility of sparks and the potential of igniting unburned fuel and/or explosive gases. It must be balanced statically and dynamically with balancing weights being an integral and non-removable part of the impeller.

C. The motor shall be a maintenance-free, variable speed motor with pre-lubricated and sealed ball bearings. The motor shall be factory warranted by the power venter manufacturer to operate at frequencies as low as 8Hz for three-phase motors. The bearings shall be of a high temperature type with a minimum rating of 320°F (160°C). The motor is mounted outside the airstream and shall be at least Class A insulated with a temperature rating of min. 221°F (105°C) and rated as shown on schedule. The motor shall be a totally enclosed, fan-cooled (TEFC) motor. To assure motor longevity the motor shall be inverter-duty rated and not operate at speeds above 1740 RPM.

D. The modulating fan control, MEC18 provided with TRIAC board module, must be a true PID-based control with infinitely variable speed settings and in a NEMA 1 rated enclosure. It shall interfere with the operation of the heating appliances by preventing burner operation during emergencies where a mechanical or electrical problem occurs. The features must be part of the compliance with UL378, Standard for Draft Equipment and UL508, Standard for Industrial Controls:

1. “Plug-and-Play” self-check that detects connections, setting requirements and accessories during each start-up.
2. Programmable microprocessor for selective programming of, but not limited to, draft, intermittent vs. continuous fan operation, purge times, sensor sensitivity, alarm limits and delays, manual overrides, low/high limit fan speeds via the operating panel or the RS-232 port.
3. A standard board that interlocks with up to 6 boilers/appliances so a call for heat activates the power venter and releases the individual burner once the pre-set draft has been established.
4. An integrated and programmable proven draft function that can be set for automatic and manual reset.
5. An integrated Operating Priority option, which allows one or more appliances to operate during electrical or mechanical failure of the fan, provided the draft requirement can be met and safe operation assured. Set up of a default Operating Priority must be possible, so the most important appliance(s) have highest priority during calls for heat. It must automatically check for fan operation every two hours and go back to normal operation if appropriate.
6. Bearing cycle activation every 7 days if the power venter has not been operating during the past 7 day period.
7. A normally open (NO) contact is available within the control to activate a visual or audible alarm (by others), or to interlock with a Building Management System.
8. An alarm function that will display the fault code on the LED display and signal an audible alarm. The control shall log the last 10 fault codes.

E. The pressure sensor, XTP2, must be certified for use with oil- or gas-fired appliances and shall include a chimney probe along with tubing for installation in the chimney or stack as shown on the manufacturer’s submittal and feature:

1. The temperature drift shall be less than +/- 1.0% full scale, the offset longtime drift (1 year) shall not exceed +/- 0.003 inWC (0.7Pa) and the sensor response time shall be less than 0.2 seconds.

F. A variable frequency drive, ABB Model Ach550, listed to UL508 and listed and programmed as part of the mechanical draft system. The VFD shall not be part of the PID-loop.

1. All features shall be included within the VFD enclosure. VFD shall be housed in a NEMA 1 enclosure.
2. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for fan control and to eliminate the need for motor de-rating.
3. With the motor’s rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor.
4. VFD shall include a “signal loss detection” circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.

2.3 PERFORMANCE, CHIMNEY AUTOMATION SYSTEM

A. The Chimney Automation System will ensure that the draft set-point (in. W.C.) is reached and maintained within 30 seconds of burner light-off. This can be measured with an external manometer at the appliance outlet.

B. Ramp-up and ramp-down time of the fan will be no more than 20 seconds.

C. The Chimney Automation System will maintain the draft at the appliance outlets to within +/- 0.01" W.C. of the draft set-point (in. W.C.) at the appliance outlets as measured with an external manometer.

D. The control will shut down the appliance(s) within 15 seconds if draft is not maintained as stated above.

2.4 STACK CONNECTION

A. Furnish a stainless steel (Model SCA) adapter plate to facilitate mounting the termination fan to the flue material.

2.5 ELECTRICAL REQUIREMENTS

A. Power supply shall be:
   1. To the EBC31 control: 1x120V AC, 60 Hz.
   2. To the variable frequency drive: As shown on schedule.

B. All wiring shall be in accordance with the National Electrical Code.

PART 3 EXECUTION

3.1 INSTALLATION

A. Complete structural, mechanical and electrical connections in accordance with manufacturers' printed instructions.

B. Installing contractor shall install all Chimney Automation System components as indicated on drawings, including low voltage wiring from XTP-Sensor to EBC 31, control, low voltage wiring from EBC 31 to VFDs, line voltage wiring to boiler panels, and power wiring from VFD's to fan motors.
   1. Allow satisfactory arrangement in the space available.
   2. Verify fan operating voltage is the equivalent to the supply voltage AND rated voltage of the VFD.

C. Connecting to the Stack: Install per plans in accordance with manufacturer's printed instructions.

3.2 OPERATING TESTS, START-UP AND ON-SITE SERVICES

A. System vendor's service organization shall employ senior service technicians having experience in all aspects of troubleshooting, corrective service and preventative maintenance and O&M reporting.

B. After installation is completed:
   1. Test the operation of the chimney automation system and:
      a. Increase and decrease draft setting to verify the mechanical draft system reacts as specified.
      b. Increase and decrease firing rate to verify the mechanical draft system reacts as specified.
      c. Verify that the ramp-up time during start up does not exceed 20 seconds. This is defined as the time from the burner is released until the draft settles at the specified draft value.
      d. Use an external manometer (draft gauge) to verify that the draft does not drift more than +/- 0.01" W.C. during a stable load.
   2. Test safety control by firing boiler and:
      a. Shut off the power venter.
      b. Shut off the control.
   3. Submit a written report signed by the manufacturer's authorized representative, confirming that safety and operating controls have been properly installed.

3.3 OPERATING INSTRUCTIONS

A. Instruct the Owner's Representative and designated personnel in the proper operation and maintenance of the packaged system.

END OF SECTION

SECTION 235216
CONDENSING BOILERS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, water-tube condensing boilers, trim, and accessories for generating hot water.

B. Related Sections
   1. Section 235100 BREECHINGS, CHIMNEYS AND STACKS.
   2. See Commissioning Requirements Section 019113.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
   1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
      a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
      b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control test reports.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

E. Other Informational Submittals:

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

   1. Warranty Period for Condensing Boilers: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

   1. Raypak.
   2. Or equal.

2.2 CONDENSING BOILERS

A. SCAQMD Certified at less than 20 ppm.

B. Description: Factory-fabricated, -assembled, and -tested, condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

C. Heat Exchanger: Finned-cupro nickel primary and stainless-steel secondary heat exchangers.

D. Combustion Chamber: Stainless steel, sealed.

E. Burner: Natural gas, forced draft drawing from gas premixing valve.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

   1. Motors: Comply with requirements specified in Section 230513 "COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT."

      a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff. 3-try type.

I. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.

J. Casing
   1. Jacket: Sheet metal, with snap-in or interlocking closures.
   2. Control Compartment Enclosures: NEMA 250, Type 1A.
   3. Finish: Textured epoxy.
   4. Insulation: Minimum 1-inch- thick, mineral-fiber insulation surrounding the heat exchanger.
   5. Combustion-Air Connections: Inlet and vent duct collars.
   6. Mounting base to secure boiler.
      a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.

2.3 TRIM

A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

G. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.4 HOT WATER BOILER TRIM

A. Safety-Relief Valve: ASME rated, factory set to protect boiler and piping as per schedule/drawings. 100 psi maximum allowable working pressure.

B. Gauge: Combination water pressure and temperature shipped factory installed. LCD outlet temperature readout to be an integral part of the front boiler control panel display to allow for consistent easy monitoring of temperatures factory mounted and wired.

C. Standard Trim
   1. Aluminum Condensate Receiver Pan
   2. Low Air Pressure Switch
   3. Blocked Flue Detection Switch
   4. Modulation Control
   5. Temperature/Pressure Gauge
   6. Manual Reset High Limit
   7. Low Gas Pressure Safety Switch
   8. Low Water Cutoff with Manual Reset
   9. Gas Pressure Regulator to provide 4” Incoming Pressure to Main Gas Valve – Shipped Loose for Field Installation.
   10. Air inlet filter
   11. Supply Outlet Temperature Display
   12. Full Digital Text Display for all Boiler Series of Operation and Failures
   13. Variable Frequency Drive and Combustion Air Fan with Safety Interlock
   14. Condensate Drain
   15. High Gas Pressure Switch and Valve Proving Switch for IRI Compliant GasTrain.

16. Flow Switch mounted and wired.
17. Isolation Valve wiring with mounted J box in rear of boiler.
18. Pump relay mounted and wired.

2.5 CONTROLS

A. Boiler operating controls shall include the following devices and features:
   1. Control transformer.
   2. Set-Point Adjust: Set points shall be adjustable.
   3. Control of multiple boilers in a master – member configuration.
      a. The master controller shall control the header/loop temperature based upon the system set point.
      b. The master controller shall stage additional boilers off and on as required and control the firing rate for all boilers in the system to optimize system performance.
   4. Sequence of Operations: Refer to section 230900 Sequence of Operations for HVAC Controls

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
   1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
   2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
   3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
   4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
   1. Digital Communication Protocol
      a. Boiler to Boiler: Manufacturer’s communication protocol.
      b. Energy Management Control System (EMCS): BACnet.
   2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.6 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
   1. House in NEMA 250, Type 1 enclosure.
   2. Wiring shall be numbered and color-coded to match wiring diagram.
   3. Install factory wiring outside of an enclosure in a meta raceway.
   4. Field power interface shall be to nonfused disconnect switch.
   5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
   6. Provide each motor with overcurrent protection.

2.7 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting: Install boilers on cast-in-place concrete equipment base(s) using elastomeric pads. Comply with requirements for equipment bases specified in Section 033000 "CAST-IN-PLACE CONCRETE." Comply with requirements for vibration isolation devices specified in Section 230548 "VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT."

1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 CONNECTIONS

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

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

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232113 "HYDRONIC PIPING."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting

1. Install flue venting kit.
2. Connect full size to boiler connections. Comply with requirements in Section 235100 "BREECHINGS, CHIMNEYS AND STACKS."

I. Ground equipment according to Section 260526 "GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS."

J. Connect wiring according to Section 260519 "LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
   a. Test for full capacity.
   b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 237315
CUSTOM CENTRAL STATION AIR HANDLING UNITS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes
   1. Variable-air-volume air-handling unit.

B. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

C. Related Sections
   1. Section 019113 – Commissioning Requirements

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 150 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.

C. Seismic Performance: Air-handling unit shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.
   1. Unit dimensions and weight.
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fans
      a. AMCA certified fan-performance curves with system operating conditions indicated.
      b. AMCA certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.
   4. AHRI certified coil-performance ratings with system operating conditions indicated.
   5. Dampers, including housings, linkages, and operators.
   6. Filters with performance characteristics.
   7. Access door detail drawing.
   8. Acoustical performance data including, inlet, outlet and casing radiated sound power levels.

B. LEED Submittal
   1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

B. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set for each air-handling unit.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain packaged custom outdoor air-handling units through one source from a single manufacturer.

B. Conform to all information documented in approved submittal package and construction notes.

C. Specified air handling units shall be factory tested as completed assemblies for vibration, sound and performance.

D. All air handling units shall be ETL listed and labeled, as completed assemblies, certifying compliance with UL 1995.

E. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged custom indoor and outdoor air handling units and are based on the specific system indicated. Refer to Section 016000 – Product Requirements.

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

G. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

H. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

I. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

J. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

K. Title 24, Part 6 of the California Code of Regulation Compliance (California Energy Code).

L. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

C. Coordinate penetrations required in the unit casing for control devices and wiring.

1.9 WARRANTY

A. Manufacturer agrees to repair or replace device/component that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following manufacturers. The contractor shall bare all costs for architectural, mechanical, structural, acoustical, seismic, electrical changes required to match the performance, fit and characteristics of the base bid equipment:

1. Energy Labs.
2. Trane.
3. Carrier.
4. Or equal.

2.2 MANUFACTURED UNITS

A. Packaged custom outdoor air-handling units shall be factory assembled and tested and consist of direct drive plenum centrifugal supply and return fans, cooling and heating coils, plenums, final filters, condensate drain pans, UV light, mixing dampers, control devices and accessories.

2.3 UNIT CASINGS

A. Materials: Formed and reinforced double wall insulated panels, fabricated to allow removal for access to internal parts and components with joints between sections sealed. Unit shall be built for outdoor installation.

B. Outside casing: Galvanized steel, 16 gauge, utilize a standing seam modular panel type construction. The panels shall be caulked and attached to each other, to the roof, and to the floor using nuts and bolts. Drive screw attachment is not acceptable. All panels shall be removable. All seams shall be sealed with an acrylic latex sealant prior to assembling the panels and after completion of the assembly. All floor openings shall have 12 gauge galvanized steel framed flange around the entire perimeter of opening for duct connection. Minimum sound transmission loss (STL) through the unit panels shall be as follows:

2 INCHES – 3 PCF INSULATION					
125	**250**	**500**	**1K**	**2K**	**4K**
25	**29**	**36**	**42**	**47**	**48**

1. Paint finish: After final assembly, the unit exterior shall be coated with an industrial grade, self-priming semi-gloss high solids 2K polyurethane gray 219GY1 finish. In addition, all fan bases, springs, and structural steel supports shall be coated with the same finish. The paint system shall meet ASTM B117 salt spray test for minimum of 2,000 hours.
2. Outdoor units shall have roofs with a minimum of 1/4-inch per foot slope to insure no standing water.
3. Inside casing: 316 stainless steel solid liner, for sections upstream and downstream of cooling coil, 20 gauge galvanized steel solid liner for remainder except use 20 gauge perforated liner in the fan sections and return air inlet plenum.
4. Floor plate: 14 gauge galvanized steel.
5. Unit base: Each unit shall be constructed on a minimum 6-inch high base fabricated from ASTM A36 welded structural steel channel. Tubular or formed metal channel bases are not acceptable. Channel bases shall be sized as a function of air handling lengths as follows:

AHU Length in Feet	Minimum Channel Size
Up to 30	8” x 2-1/2” (11.5 lbs/linear ft.)
31 to 40	10” x 2-3/4” (15.3 lbs/linear ft.)
41 to 50	12” x 3” (20.7 lbs/linear ft.)

   a. Heavy removable lifting lugs shall be added to the perimeter channel along the longest length of the unit. The unit floor shall be fabricated of 0.125-inch thick, #3003 aluminum tread plate sheets. The floor shall be supported by structural and minimum 12 gauge formed galvanized steel members. Max spacing of floor support shall be 24-inch centers. These formed members shall be welded to other members for maximum strength. Floor skin shall be supplied with standing seams design and drive cleats to maintain water and airtight seal. The flooring shall be spot welded to the members below. No penetrations thru the floor skin shall be acceptable. Welds shall be below the floor and spaced no greater than 6 inches on center.
   b. Fans, coils and major components shall be supported with structural steel members directly below these items.

C. Casing Insulation and Adhesive

1. Materials: ASTM C 1071, Type II, with neoprene coated surface to cover all walls and ceiling surfaces exposed to air stream to prevent erosion of glass fibers. There shall be no raw edges of insulation exposed to the air stream.
2. Thickness: 2 inches, 3 lbs per cubic feet density.
3. Thermal conductivity (k-value): 0.26 at 75 degrees F mean temperature.
4. Fire Hazard Classification: Maximum flame spread to meet NFPA 90A smoke and flame spread requirements.
5. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C916.
6. 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 cabinet.
7. Location and application: Encased between outside and inside casing.
8. All floors shall be insulated from below using minimum 2-inches thick foam to insure that the entire under surface of the floor is insulated. Liner shall be 20 gauge G90 solid galvanized steel.

D. Inspection and Access Panels and Access Doors

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels
    a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
    b. Gasket: Closed cell hollow round gasketing, applied around entire perimeters of panel frames with a metal encapsulated reinforced backing mechanically fastened to the door frame.
    c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
3. Access Doors
    a. All access doors shall be of thermal break construction, hinged, double wall, insulated, man size access doors shall be provided in all sections requiring access for maintenance or service. Operable door latches shall be provided on either side of the door.
    b. Frame: Extruded aluminum, fully welded at the corners with an anodized finish.
    c. Hardware: Shall be non-corrosive and all hinges and latches shall be adjustable with nuts and bolts.
    d. Maximum leakage: Less than 25 CFM @ 6 inches wg static pressure.
    e. Hinges: Door hinges and latches shall be easily adjustable, without the use of shims or special tools, to allow for a tight seal between the door and the doorframe as the gasketing material compresses over time. The door hinge design shall allow for field reversing of door swing and doors shall be easily removable.
    f. Doors entering into any section of the air handler that contains rotating fans shall be provided with a door interlock safety switch to de-energize the fan motor upon opening.
    g. Gasket: Dual gasket seal system, applied around entire perimeters of panel frames.
    h. Provide minimum 8 inch x 12 inch or 12 inch round windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
    i. Size: At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.
4. Locations and Applications
    a. Fan Section: Doors.
    b. Access Section: Doors.
    c. Coil Section: Doors.
    d. Damper Section: Doors.
    e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
    f. Mixing Section: Doors.
5. Service Light: 100-W fluorescent vaporproof fixture and switched junction box located outside adjacent to door.
    a. Locations: Each section accessed with door.
    b. Switch location: Outside supply fan section with 60 minute timer.

E. Controls Openings

1. Provide factory panel and penetrations for controls devices and wiring. Field penetrations of the unit casing are not permitted. Controls cabinet size shall be coordinated with controls manufacturer prior to installation at factory.

F. Condensate Drain Pans

1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and to direct water toward drain connection.
    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-2007.
    b. Depth: A minimum of 2 inches deep.
2. Integral part of floor plating.
3. Double-wall, (16 gage) 316 stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan at the side of the unit.

5. Units with multiple stacked coils and single coils greater than 48 inches shall have an intermediate drain pan to collect condensate from top coil. The pans shall be min. 0.064 inch (16 gage) 316 stainless steel and drain to the main drain pan through copper downspouts.
6. Drain pan shall be insulated with 2 inches of 1.5 lbm/cu.ft. density insulation to prevent condensation under the drain pan. Insulation shall be protected with an 0.064 inch (16 gage) galvanized steel liner.
7. Drain pans shall be sized such that the entire coil, including headers and return bends are inside the drain pan.

G. Air-Handling-Unit Mounting Frame: ASTM A36 welded structural steel channel or tubular base designed for low deflection, with removable lifting lugs.
   1. Steel bases shall be sized as a function of the air handling length.
   2. Units less than or equal to 20 feet in length shall have a minimum 4 inch channel and units greater than 20 feet in length shall have a minimum 6 inch channel.
   3. Deflection of the frame members shall be limited to L/200.
   4. Intermediate tubular steel cross members shall be fully welded and located at lighting points and as need to support internal components such as coils and fans.
   5. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 – Vibration and Seismic Controls for HVAC Piping and Equipment when air-handling unit frame is anchored to building structure.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
   1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
      a. Turned, ground, and polished hot-rolled ASI C-1018, 1040 or 1045 steel with keyway. Ship with a protective coating of lubricating oil.
      b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
      c. Fan selection shall meet scheduled minimum efficiencies.
      d. Motor brake horsepower shall meet the scheduled maximum values.

B. Fan Base: The fan and motor shall be mounted on an all welded, structural steel, prime coated, internal isolation base with springs selected to provide 99 percent isolation efficiency from the building structure. The internally mounted motor shall be provided on a slide rail base to allow proper adjustment of belt tension.

C. Sound Performance: All fans shall be AMCA certified. Non-certified AMCA fan data is not acceptable.

D. Plenum fans shall be configured so that both fan bearings are on the drive side of the wheel with the wheel over hung (Arrangement #4 for all direct drive fans).
   1. Supply fan shall be direct drive Arrangement #4 whenever possible.
   2. There shall be no obstructions (i.e., bearings or bearing supports, etc.,) at the inlet of the fan. Fan wheel shall be aluminum with aluminum extruded airfoil blades.

E. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

F. All fans shall be provided with spring-style thrust restraints.

G. Fan Shaft Bearings
   1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   2. All fan bearings shall be selected for a minimum service life of ASTM L-10 200,000 hours.
   3. Fan bearings shall be mounted on a structural steel channel or machined surface.

H. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices. Refer to Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT, for requirements.

   1. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.

I. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

   1. Enclosure Type: Totally enclosed, fan cooled.
   2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   5. The motor shall be mounted on an adjustable slide rail motor base with two adjusting bolts per side.
   6. Mount unit-mounted disconnect switches on exterior of unit.
   7. Motors shall be mounted and isolated on the same integral base as the fan

2.5 COIL SECTION

A. General requirements for coil section.

   1. Continuous circuit coil fabricated according to ARI 410.
      a. Threaded piping connections on same end.
      b. Tubes: 0.20” copper, with individually replaceable copper return bends of 0.025” wall thickness on both sides of the coil. Coils incorporating a hairpin type design are not acceptable.
      c. Fins: 0.008” aluminum with fin spacing not closer than 12 fins per inch.
      d. Fin and Tube Joint: Mechanical bond.
      e. Headers shall be non-ferrous seamless copper, outside the air stream but inside the cabinet casing and provided with brazed copper male pipe connections that extend through the air handler casing. Drain and vent tubes shall be extended to the exterior of the air handling unit.
      f. Blank-offs: All sides of coils shall be carefully blanked off with the same materials used for the coil casings, to ensure all air passes through the coil.
      g. Casings: Casings shall be minimum 16 gauge, 316 stainless steel with double formed 1-1/4 inch stacking flanges and 3/4 inch flanges on the side plates. All other coil casing shall be of 16-gauge galvanized steel. Reinforcing shall be furnished so that the unsupported length is not over 60 inches.
      h. Intermediate drain pans are to be furnished on multiple coil units and single coils greater than 48 inches high. The pans shall be 16 gauge 316 stainless steel and drain to the main drain pan through copper downspouts.
   2. All coils shall have counter flow construction with connections left or right hand as shown on the drawings. The use of internal restrictive devices to obtain turbulent flow will not be accepted.
   3. Coils shall not act as structural component of unit.
   4. Coil headers shall be located inside of the cabinet casing with only the pipe connections extending through the casing.
   5. Tubes shall be expanded into the fin collars to provide a permanent mechanical bond.
   6. Flanged tube sheets shall have extruded tube holes to prevent raw edges of tube sheets cut into copper tubes because of thermal expansion of tubes in tube holes. Tube holes with raw sheet metal edges are not acceptable.
   7. All coil assemblies shall be tested under water at 300 psi.
   8. Coil face velocities shall be sized according to schedule.

9. Coils shall be fully enclosed within the casing mounted angle racks manufactured to allow coils to slide out individually.
10. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT, when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.

2.6 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section
   1. Comply with NFPA 90A.
   2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   3. Filter sections shall be fabricated as part of the air-handling unit. Filters shall be arranged for upstream, downstream, or side loading as shown on the drawings. Provide filter holding frames to accommodate scheduled filters.
   4. Frame: 0.064 inch (16 gage) galvanized steel, and shall be fully welded to reduce leakage of air through corners.

B. Mini-Pleat Box Filters
   1. Factory-fabricated, dry, packaged air filters, extended-surface type.
   2. Thickness: 12 inches.
   3. Initial Resistance: shall not exceed 0.30” at 500 fpm when clean.
   4. Recommended Final Resistance: 1 inch wg.
   5. Arrestance (ASHRAE 52.1): 90.
   6. MERV (ASHRAE 52.2): 13.
   7. Media: Fibrous material formed into deep-V-shaped mini-pleats with antimicrobial agent and held by self-supporting wire grid.
   8. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.

C. Filter Gage
   1. 3-1/2-inch diameter, diaphragm-actuated dial with signal flag in metal case.
   2. Vent valves.
   3. Black figures on white background.
   4. Front recalibration adjustment.
   5. 2 percent of full-scale accuracy.
   6. Range: 0- to 2.0-inch wg.
   7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch tubing, and 2- or 3-way vent valves.

2.7 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

B. Dampers shall be sized for a maximum face velocity of 1200 fpm based upon gross damper area. Furnish full height 24 inches wide access doors for damper and linkage service.

C. Dampers shall be supplied with low leak extruded aluminum airfoil blades. Blades shall be supplied with rubber edge seals and stainless steel arc end seals. Rubber edge seals shall be backed by the damper blade to assure a positive seal in the closed position. Dampers shall be provided with nylon bearings within extruded openings. Damper leakage shall not exceed 6 cfm/sq.ft. at 5 inch w.g. of static pressure. Leakage testing shall be in accordance with AMCA standard 500 figure 5.5. Test results must be from independent testing laboratory.

2.8 LOUVERS

A. Provide louvers for outside air and exhaust air.

B. Outside air louvers shall be sized for a maximum velocity of 500 fpm and exhaust air louvers shall be sized for a maximum face velocity of 800 fpm based on gross louver area.

C. Louvers shall have zero water penetration at 600 fpm air velocity.

D. Provide test results from independent testing laboratory. Test must be conducted in accordance to AMCA Standard 500 Figure 5.5.

E. Louver water carry over must be less than 0.01 oz/sq.ft. at 1,100 fpm of free louver area. Test must be conducted by an independent testing laboratory per AMCA 500-89, Figure 5.6.

F. Hoods in lieu of louvers are not acceptable.

2.9 CONTROLS REQUIREMENTS

A. Required air handling unit mounted control enclosures, controllers, control devices and wiring shall be mounted in the factory. Field mounted enclosures, penetrations and conduit and/or wiring is not permitted.

B. The manufacturer shall provide NEMA 3R steel enclosure painted to match the unit casing attached to these conduits for the controls contractor to install their control panel in the field. Size of the enclosure shall be coordinated with controls manufacturer.

C. Refer to the following sections for additional requirements:
   1. 230913, “BUILDING AUTOMATION SYSTEM FOR HVAC.”
   2. 230923, “INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.”

D. Provide an airflow monitoring station for each fan. Airflow monitoring station shall display a reading as well as allow an analog output to the EMCS. Multiple fans on a common bank shall have individual sensors per fan with a common transmitter indicating total airflow.
   1. Manufacturer shall be Ebtron, Fan Inlet Hybrid Series or equal.
   2. Fan shall have a sensor face mounted at the inlet cone without affecting fan performance or sound. Each sensor node shall contain two individually wired, hermetically sealed bead-in-glass thermistors. Airflow accuracy shall be +/- 2% of reading over the entire operating airflow range of not less than 0 to 10,000 cfm.
   3. The transmitter shall have an integral, minimum 16 character LCD display shall also be capable of displaying individual airflow and temperature readings of each independent sensor node.
   4. Output signal 4-20 mA. DC or 0-5 VDC standard.
   5. The transmitter shall be housed in a NEMA 3R enclosure with external signal tubing, power and output signal connections.

E. Provide an airflow monitoring station for outside airflow monitoring. Airflow monitoring station shall display a reading as well as allow an analog output to the EMCS.
   1. Manufacturer shall be Ebtron, or equal.
   2. Sensor node shall contain two individually wired, hermetically sealed bead-in-glass thermistors. Airflow accuracy shall be +/- 2% of reading over the entire operating airflow range of not less than 0 to 40,000 cfm.
   3. The transmitter shall have an integral, minimum 16 character LCD display shall also be capable of displaying individual airflow and temperature readings of each independent sensor node.
   4. Output signal 4-20 mA. DC or 0-5 VDC standard.
   5. The transmitter shall be housed in a NEMA 3R enclosure with external signal tubing, power and output signal connections.

2.10 VARIABLE FREQUENCY DRIVES

A. General: Furnish complete individual variable frequency VFDs for each fan designated on the drawing schedules to be variable speed with requirements in Section 262923 VARIABLE FREQUENCY MOTOR CONTROLLERS.

2.11 ELECTRICAL REQUIREMENTS

A. All air handling unit and electrical panel wiring shall be performed in a UL 508 listed shop.

B. Provide single source power panels (SSPP’s) that are constructed according to NEC regulations and carry a UL 508 listing and label.
   1. The panel shall include a non-fused main disconnect switch covering all fans in each unit, VFDs for variable volume units, and any necessary transformers, Hand–Off–Auto switches, relays and pilot lights for complete operation of the fans in the unit.
   2. The single source power panels shall be factory wired to all factory furnished devices such as motors and interlocks.

C. The air handling unit manufacturer, for the purpose of sole source responsibility, shall manufacture all electrical panel assemblies supplied for the air handlers. The air handling unit manufacturer shall be a UL 508 listed panel shop.

D. The main control panel shall have access door(s) for direct access to the controls. The panel shall be NEMA Type 3R and shall contain a single externally operated, non-fused disconnect, suitable for copper wire up to and including 3-inch conduit.

E. All wiring shall be run in EMT conduit, (or flexible when connecting to a motor), raceways are not acceptable.

F. Where unit requires splits, junction boxes shall be furnished on each section to allow the electrical contractor to make final connections in the field. Wiring shall be clearly labeled to allow ease in final interconnections.

2.12 ULTRAVIOLET (UV) GERMICIDAL LAMPS

A. A heavy duty UVC germicidal irradiation system using short wave UVC germicidal lamps shall be furnished as described herein.

B. The air-handling unit manufacturer shall furnish and install, including interconnecting wiring and safety interlocks, a germicidal UVC irradiation system.

C. Intensity
   1. The minimal UV energy striking a targeted surface shall be sufficient to destroy a monolayer of common mold and fungi within 6 hours.
   2. Lamps and fixtures are to be installed in sufficient quantity in such a manner to insure equal distribution of UV energy across the cooling face and drain pans.

D. Testing and Safety Listing
   1. UV fixtures shall have been tested and listed as UL/C-UL under category code ABQK (Accessories, Air Duct Mounted), UL Standards 153, 1598 and 1995 respectively, no exceptions.
   2. Manufacturer of UVC components shall be ISO 9001 certified.

E. Installation by Air Handling Unit Manufacturer
   1. Air handling unit factory authorized and trained service technicians shall install the tubes in the air handling units after the units have been installed.
   2. UV light manufacturer is to certify installation has been such that UV reflective and shadowed energy losses are the lowest possible.
   3. Cumulative sum length of UV fixtures end-to-end shall equal the coil width plus or minus 3 inches.
   4. System shall be installed a minimum of 9 inches and maximum of 20 inches from coil surface (based on manufacturer’s calculations and recommendations).
   5. One row of lamps shall serve not more than 48 inches of coil height.
   6. Installation shall be installed on tracks allowing the UV fixture to slide into place. Tracks shall be designed in such a manner the UV fixture can be easily removed and maintained or replaced. Multiple UV assemblies shall connect via interlock.
   7. Fixture rows shall be terminated (for safety) to factory supplied hard-wired module.
   8. Light rows shall be mounted so UVC covers the entire coil face and drain pan surfaces as well as line of sight air stream.
   9. Air handling unit manufacturer installation shall include all mechanical interlock and wiring to assure UV light assembly is not energized when any access door is opened.

10. For future reference, the air handling unit manufacturer shall include detailed and certified drawings locating the fixtures. Drawings shall also be included in all operation and maintenance manuals.

F. Lamps
   1. Each lamp shall contain no more than 8 milligrams of mercury consistent with current environmental practices and shall be capable of producing its specified output in temperature of 55-135 deg F and airflow velocities up to 1,000 fpm.
   2. Useful lamp life shall be 9,000 hours with no more than 20 percent output loss at the end of one year continuous use.
   3. Lamps shall be constructed of UV proof metal bases and shall not produce ozone or other secondary containment.

G. Fixtures
   1. Each fixture shall be constructed of stainless steel. Galvanized steel or aluminum is not acceptable. All integral parts of the fixture shall be self-contained.
   2. Fixtures constructed to UL drip proof design and equipped with safety approved fixture-to-fixture plugs to facilitate UL approved multiple fixture and row coupling to A/C power.
   3. The UV assembly shall include mechanical interlocks to prevent energizing unless the system is properly installed.

H. Power Supplies
   1. The power supply shall be electronic, high efficiency type capable of producing the required coverage at no more than 80 watts of power consumption for each for square feet of cross sectional plenum area. Power supply shall be 120 VAC, 60 hertz.
   2. Power supply shall be matched to the lamp and designed to maximize photon production, radiance and reliability.
   3. Electronic power supply shall be UL listed for application in airstreams between 55-135 deg F.

I. Portal: The UV lamp plenum area shall be equipped with a portal for viewing the lamp assembly. Portal shall be constructed to allow viewing without the possibility of exceeding the minimal erythemal dose.

J. Provide exterior switch to control UV lights and interlink with section door to turn off lights whenever door is open.

2.13 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Unit Sound Power Levels
   1. Factory Testing Requirements
      a. Perform factory sound tests for all air handling units. All costs associated with remedial measures to comply with the specifications shall be borne by the air handling unit manufacturer:
      b. Tests shall be carried out in accordance with AMCA Standard 300-96 Reverberant Room Method for sound testing of fans, and AMCA Standard 210, Laboratory Methods of Testing Fans for rating.
      c. All testing shall be conducted in a laboratory AMCA certified for both sound and performance.
      d. Sound power data shall be given at the supply connection(s) (outlet), return connection(s) (inlet), outside air connection(s) (inlet) and exhaust connection(s) (outlet) in addition to radiated sound power from the cabinet.
         1) Raw fan sound power data shall be derived from tests done in accordance with AMCA Standard 300-96.
         2) Data extrapolated from non-like fan sizes and types scheduled are not acceptable.

3) Attenuation assumed for the cabinet configuration, type of insulation, opening locations and sizes, etc., shall be verified through actual test measurements.
4) The Owner's Representative may, at his option, request copies of such tests.

2. The air-handling unit equipment manufacturer shall furnish calculations showing the estimated sound power levels for each supply air, return air, exhaust air and outside air opening and unit casing radiation for each air-handling unit.
3. Applicable Standards: All sound power level measurements shall be made in complete accordance with the latest version of ARI Standard 260, Sound Rating of Ducted Air Moving and Conditioning Equipment or a test method approved by the acoustical consultant. All testing shall be conducted in an AMCA certified testing laboratory. Equivalent test procedures may be substituted for the above procedures if approved in advance by the Owner's Representative.
4. The sound power level of the air-handling unit's supply air, return air, exhaust air and outside air openings and case-radiated noise shall not exceed the values list in the Air-Handling Unit Schedule below when operating at the maximum design airflow and static pressure conditions.

D. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Section 033000 – CAST IN PLACE CONCRETE."

1. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance. Chilled water pipe connection to cooling coils and heating hot water pipe connections to heating coil shall be offset from the coil and shall not interfere with coil pull space or access doors into the air handling unit. Contractor shall coordinate exact location with air-handling unit manufacturer.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor sink. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Chilled-Water and Heating Hot Water Piping: Comply with applicable requirements in Section 232113 – HYDRONIC PIPING. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 – AIR DUCT ACCESSORIES.

G. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

H. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

I. 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 inspect, test, and adjust components, assemblies, and equipment installations, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to provide start-up assistance

B. Final checks before start-up: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
3. Perform cleaning and adjusting specified in this section.
4. Disconnect fan drive from motor. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that zone dampers are in full open position for each zone.
6. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Install new, clean filters.
11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. 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.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 – TESTING, ADJUSTING AND BALANCING FOR HVAC for air handling system testing, adjusting, and balancing.

3.7 CLEANING

A. Clean packaged custom outdoor air handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting and balancing packaged custom air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain air-handling units. Refer to Section 017900 – DEMONSTRATION AND TRAINING.

END OF SECTION

SECTION 237413
PACKAGED DIRECT EXPANSION AIR HANDLING UNITS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
   1. Direct-expansion cooling.
   2. Heat-pump refrigeration components.
   3. Gas furnace.
   4. Integral, space temperature controls.
   5. Roof curbs.

B. Related Sections include the following:
   1. See Commissioning Requirements Section 019113.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. Outdoor Air Refrigerant Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air conditioning, heating, or ventilating apparatus.

G. Supply Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design RTU supports to comply with wind and seismic performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance
   1. Basic Wind Speed: 110 mph.
   2. Building Classification Category: III.
   3. Minimum 10 lb/sq. ft multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. LEED Submittals

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 – "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

D. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

E. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

B. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" Article and in Section 230548 – Vibration and Seismic Controls for HVAC Piping and Equipment.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports.

E. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-driven fan.
2. Filters: One set of filters for each unit.

1.8 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 – "Systems and Equipment" and Section 7 – "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 – "Heating, Ventilating, and Air Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. 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.

G. Gas-fired heating rooftop units shall conform to ANSI Z21.47 for construction of packaged air conditioner.

H. Gas-fired heating rooftop units shall conform to UL 795 for construction of packaged air conditioner.

I. Title 24, Part 6 of the California Code of Regulation Compliance.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   1. Trane; American Standard Companies, Inc.
   2. AAON, Inc.
   3. Carrier Corporation.
   4. YORK International Corporation.
   5. Or equal.

2.2 CASING

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
   1. Exterior Casing Thickness: min. 0.052 inch thick.

C. Inner Casing Fabrication Requirements
   1. Inside Casing: Galvanized steel, min. 0.034-inch thick, perforated 40 percent free area.

D. Access doors shall be provided with door handles that can be operated manually by hand without use of tools.

E. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   1. Materials: ASTM C 1071, Type I.
   2. Thickness: 1/2-inch.
   3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
   4. Liner Adhesive: Comply with ASTM C 916, Type I.

F. Condensate Drain Pans: Formed sections of stainless-steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1.
   1. Double Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
   2. Drain Connections: Threaded nipple both sides of drain pan.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.3 FANS

A. Direct Driven Supply Air Fans: plenum fan; with permanently lubricated, ECM motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Condenser Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

C. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT when fan mounted frame and RTU mounted frame are anchored to building structure.

D. Bearings shall be selected for a minimum L10 life in excess of 200,000 hours at maximum catalogued operating speed.

E. Fan Motor: Comply with requirements in Section 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

2.4 COILS

A. Supply-Air Refrigerant Coil

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Baked phenolic coating.
5. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Outdoor-Air Refrigerant Coil

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Baked phenolic coating.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties

1. Refrigerant: R-407C or R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter / dryer.
4. Manual reset high-pressure safety switch.
5. Automatic reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low ambient kit high-pressure sensor.
10. Hot gas reheat solenoid valve with a replaceable magnetic coil.
11. Hot gas bypass solenoid valve with a replaceable magnetic coil.
12. Four way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated: Minimum 85 percent arrestance when tested in accordance with ASHRAE 52.1, and MERV 13 category 52.2 ASHRAE test standard.

2.7 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

E. Safety Controls

1. Gas Control Valve: Modulating.
2. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.8 DAMPERS

A. Outdoor and Return Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
   1. Damper Motor: Modulating with adjustable minimum position.
   2. Relief Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

2.9 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230900 – INSTRUMENTATION AND CONTROL FOR HVAC.

B. Basic Unit Controls
   1. Control voltage transformer.
   2. Wall-mounted thermostat or sensor with the following features:
      a. Heat-cool-off switch.
      b. Fan on-auto switch.
      c. Fan-speed switch.
      d. Automatic changeover.
      e. Adjustable deadband.
      f. Exposed set point.
      g. Exposed indication.
      h. Degree F indication.
      i. Unoccupied-period-override push button.
      j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.
   3. Wall-mounted humidistat or sensor with the following features:
      a. Exposed set point.
      b. Exposed indication.
   4. Unit-Mounted Annunciator Panel for Each Unit
      a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
      b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
      c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

C. DDC Controller
   1. Controller shall have volatile-memory backup.
   2. Safety Control Operation
      a. Firestats: Stop fan and close outdoor-air damper if air greater than 120 degrees F enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
      b. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 283111 – DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM.
      c. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 degrees F.
      d. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
   3. Scheduled Operation: Occupied and unoccupied periods on 365-day clock with a minimum of four programmable periods per day.
   4. Unoccupied Period:
      a. Override Operation: Two hours.

5. Supply Fan Operation
    a. Occupied Periods: Run fan continuously.
    b. Unoccupied Periods: Cycle fan to maintain setback temperature.
6. Gas Furnace Operation
    a. Occupied Periods: Modulate burner to maintain discharge temperature.
    b. Unoccupied Periods: Cycle burner to maintain setback temperature.
7. Fixed Minimum Outdoor-Air Damper Operation
    a. Occupied Periods: Open to minimum outdoor air position based upon scheduled airflow and field verification.
    b. Unoccupied Periods: Close the outdoor-air damper.

D. Interface Requirements for HVAC Instrumentation and Control System
1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:
    a. Unit Status Reports
        1) Adjusting setpoints.
            (a) Active cooling/supply air setpoint
            (b) Active heating/supply air setpoint
            (c) Space temperature
        2) Monitoring supply fan start, stop, and operation.
        3) Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
        4) Monitoring occupied and unoccupied operations.
        5) Operating mode
        6) Active rooftop diagnostics
        7) Active cooling/heating mode
        8) Supply air temperature
        9) Supply fan status
        10) Supply fan percent modulation
        11) Active space pressure
        12) Active supply air pressure
        13) Compressor on/off status
        14) Condenser on/off status
        15) Heat stage on/off status
        16) Hydronic heat output
        17) Monitoring constant and variable motor loads.
        18) Monitoring cooling load.
        19) Outdoor air flow
        20) Monitoring air-distribution static pressure and ventilation air volume.
    b. Individual rooftop diagnostic and alarm statuses shall include the following latching items for each rooftop unit:
        1) Emergency stop
        2) Supply fan failure
        3) Compressor trip (each circuit)
        4) Manual supply air static pressure limit
        5) Compressor contactor fail (each circuit)
    c. Individual rooftop diagnostic and alarm statuses shall include the following non-latching items for each rooftop unit:
        1) Zone temperature sensor failure
        2) Supply air temperature sensor failure
        3) Auxiliary temperature sensor failure
        4) Outdoor air temperature sensor failure
        5) Occupied zone cool/heat setpoint failure
        6) Supply air pressure sensor failure
        7) Outdoor air humidity sensor failure
        8) Evaporator temperature sensor failure (each circuit)
        9) Condenser Temperature sensor failure (each circuit)
        10) Morning warm-up zone sensor fail

11) Heat failure
12) Unoccupied zone cool/heat setpoint failure
13) Supply air pressure setpoint failure
14) Space static pressure setpoint failure
15) Space pressure sensor failure
16) Return air temperature sensor failure
17) Return air humidity sensor failure
18) Auto supply air static pressure limit
19) Unit communications loss
20) Heat communications failure
21) Night setback panel communications failure
22) Ventilation override mode communications loss
23) Supply air temperature cool/heat setpoint fail
24) Dirty filter
25) Night setback zone temperature sensor fail

2.11 ACCESSORIES

A. Duplex, 115 V, ground-fault-interrupter outlet with 15 A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Coil guards of painted, galvanized-steel wire.

D. Hail guards of galvanized steel, painted to match casing.

E. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

2.12 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVACE PIPING AND EQUIPMENT.

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
      a. Materials: ASTM C 1071, Type I or II.
      b. Thickness: 2 inches.
   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
      b. 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 cabinet.
      c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
      d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: 14 inches.

D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT, for wind-load requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install RTUs on concrete base. Comply with requirements for vibration isolation devices and seismic restraint specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT. Comply with requirements for concrete base specified in Section 033000 – CAST-IN-PLACE CONCRETE.

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 – ROOF ACCESSORIES. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

D. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTUs to allow service and maintenance.

C. Gas Piping: Comply with applicable requirements in Section 231123 – FACILITY NATURAL GAS PIPING. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

D. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 – AIR DUCT ACCESSORIES.
   4. Install return-air duct continuously through roof structure.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks per manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit per manufacturer's written instructions.
    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.
18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 degrees F above return-air temperature:
    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
    a. Supply-air volume.
    b. Outdoor-air intake volume.
27. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.

   b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Firestat alarm.
29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Campus maintenance personnel to adjust, operate, and maintain RTUs. Refer to Section 017900 – DEMONSTRATION AND TRAINING.

END OF SECTION

SECTION 238126
VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes information on the general requirements for work completed under Division 23.

B. Related Sections

1. See Commissioning Requirements Section 019113.

C. This project is required to achieve certification under LEED-NC v 2009. The green building parameters required for this affect all aspects of construction. Materials in this section may be subject to the requirements of IEQc4.1, IEQc4.2 and/or IEQc4.4. Please review the LEED Requirements Section 018113 of this Specifications Manual.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. LEED Submittals

1. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Furnish submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved

1. Ceiling suspension components.
2. Structural members to which fan-coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of fan-coil unit indicated.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals.

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

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 the Owner's Representative, and marked for intended use.

   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

1.4 COORDINATION

A. Coordinate layout and installation of units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Fan Coil Unit Filter: Furnish one spare filters for each filter installed.
   2. Fan Belts: Furnish one spare fan belt for each unit installed.

1.6 WARRANTY

A. Manufacturer agrees to repair or replace equipment/device/component that fail in materials or workmanship within specified warranty period.

   1. Warranty Period: 2 years from date of Substantial completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Basis of design manufacturer is Trane or equal.

2.2 WALL MOUNTED FAN COIL

A. Cabinet: Manufacturer standard panels in white color.

   1. Insulation: Foamed Polystyrene/Foamed Polyethylene.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.

C. Fan: Cross Flow.

D. Air Filtration Section:

   1. Resin Net (washable)
      a. Comply with NFPA 90A.
      b. Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
      c. Filter-Holding Frames: Arranged for flat or angular orientation, with access doors. Filters shall be removable from one side.

E. Motors: Comply with requirements in Section 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

F. Control devices and operational sequences are specified in Section 230923 "INSTRUMENTATION AND CONTROL DEVICES FOR HVAC."

   1. DDC Terminal Controller
      a. Scheduled Operation: Fan cycles to maintain room setback temperature. Provide seven-day clock with a minimum of four programmable periods per day.

G. EMCS Interface Requirements

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide interface for central EMCS workstation for the following functions:
    a. Adjust setpoints.
    b. Fan-coil-unit start, stop, and operating status.
    c. Data inquiry, including supply- and room-air temperature.

H. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER UNIT, HEAT PUMP

A. General: The outdoor unit is designed specifically for use with Trane components or equal.

1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator. High/low pressure gas line, liquid and suction lines must be individually insulated between the outdoor and indoor units.
2. The outdoor unit can be wired and piped with outdoor unit access from the left, right, rear or bottom.
3. The connection ratio of indoor units to outdoor unit shall be permitted up to 200 percent.
4. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
5. The unit shall incorporate an auto-charging feature and a refrigerant charge check function.
6. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
7. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
8. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature.
9. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.
10. The outdoor unit shall be capable of heating operation at 0 degrees F dry bulb ambient temperature without additional low ambient controls.
11. The system shall continue to provide heat to the indoor units in heating operation while in the defrost mode. Reverse cycle (cooling mode) defrost during heating operation shall not be permitted due to the potential reduction in space temperature

B. Unit Cabinet: The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

C. Fan

1. The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12-inch WG. A field setting switch to a maximum 0.32-inch WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
4. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

D. Condenser Coil

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.

3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.
5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

E. Compressor

1. The inverter scroll compressors shall be variable speed (PAM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.
2. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
3. The capacity control range shall be as low as 6 percent to 100 percent.
4. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
5. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
6. Oil separators shall be standard with the equipment together with an intelligent oil management system.
7. The compressor shall be spring mounted to avoid the transmission of vibration.

F. Electrical

1. The power supply to the outdoor unit shall be 208 volts, 3 phase, 60 Hertz +/- 10 percent.
2. The control voltage between the indoor and outdoor unit shall be 16 VDC non-shielded, stranded 2 conductor cable.
3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.
4. The control wiring lengths shall be as shown below.

	Outdoor to Indoor Unit	**Outdoor to Central Controller**	**Indoor Unit to Remote Control**
Control Wiring Length	6,665 feet	3,330 feet	1,665 feet
Wire Type	16 AWG, 2 wire, non-polarity, non-shielded, stranded		

2.4 CONTROLS

A. Centralized Controller shall be provided to allow operation of entire system and individual zones from a central controller and through the web via Ethernet connection.

1. The controller system shall be a neutral color plastic material.
2. The controller shall include a minimum 5.7-inch Liquid Crystal Display (LCD, QVGA 320x240, 4096 colors).

B. Electrical Characteristics

1. Control Wiring Size: The wire shall be a non-shielded, stranded, 2 conductor PVC or vinyl clad cable. 18-gauge copper cabling specified. Application of UV stabilized cable should be standard when exposed to outside elements. Plenum rated where applicable. Maximum wiring length between controller and indoor units: 3,280 feet

2. Power Supply to controller shall be 24V AC (transformer to be field supplied by contractor)

C. Operating Characteristics

1. The Intelligent controller shall be able to control, via a full color LCD touch screen, up to 10 outdoor units and 64 indoor unit groups (maximum 128 Fan Coil Units) with the following functions:
2. ON/OFF selection for each Fan Coil Unit or group.
3. Temperature set point adjustment for each Fan Coil Unit or group.
4. Fan speed adjustment for each Fan Coil Unit or group
5. Heat/cool/automatic changeover mode selection
6. Forced shutdown terminals
7. Priority settings for restriction of local access for start/stop, heat/cool mode and set point adjustment (at local remote controllers if installed)
8. Temperature limitation in both heating and cooling mode
9. Weekly schedule with startup and shut off times, temperature settings and operation modes; 16 operations / each day can be set in one schedule, and 8 different schedules are available. In addition a yearly calendar is also available for holidays or periods of non-use
10. Actual time display and setting
11. Reset ability for malfunction codes and filter maintenance warning
12. Automatic Changeover Routine: Allows 3 methods for changeover of a defined zone (i.e. one fan coil or more) based on averaging, fixed, or operating.
13. Zone Temperature Limit Capability (Occupied and Unoccupied)
14. Heating Optimization Routine. Always overheating fan coils to cycle fan.
15. Maximum 13 months back up power supply to maintain the memory.
16. Web enabled feature shall allow operation of I-Touch controller through the web via Ethernet connection.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 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-mounted, compressor-condenser components on 6-inch-thick, reinforced concrete base; 6 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 033000 – Cast-in-Place Concrete. Coordinate anchor installation with concrete base.

D. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Section 230548 – Vibration and Seismic Controls for HVAC Piping and Equipment.

E. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Suspend fan-coil units from structure with hangers. Vibration isolators are specified Section 230548 – Vibration and Seismic Controls for HVAC.

G. Verify locations of thermostats, and other exposed control sensors with Drawings and room details before installation.

H. Install new filters in fan-coil unit within two weeks after Substantial Completion.

3.3 FIELD-INSTALLED REFRIGERANT PIPING

A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

B. Install piping adjacent to unit to allow service and maintenance.

C. Piping shall be copper with joints brazed with 15 percent silver, silphos brazing rod.

D. Elbows shall be of the long radius type.

E. Refrigerant piping shall be insulated with 1-inch-thick closed cell rubberized insulation.

F. Piping shall be secured to structure with straps, taking care to ensure that the liquid line does not contact the structure and that the insulation is not torn.

G. Piping shall be purged with dry nitrogen prior to evacuation and charging with refrigerant.

H. Piping installation requirements are specified in 232300 – Refrigerant Piping. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

I. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

J. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test and adjust components, assemblies and equipment installation, including connections. Report results in writing.

B. Tests and Inspections:
   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 safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature setpoints.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain fan-coil units.

END OF SECTION

SECTION 238219
FAN COIL UNITS

PART 1 GENERAL

1.1 SUMMARY

A. This section includes chilled water fan coil units and accessories.

1.2 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Achievement of LEED-NC v2009 requires specific forms of documentation as part of the materials submittals to document certain product properties. Review the LEED Requirements Section 018113 of this Specifications Manual. Provide submittals as required in Section 018113-1.4 for all relevant materials in this section.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 – Operation and Maintenance Data, include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.4 MAINTENANCE MATERIAL SUBMITTAL

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish one spare filters for each filter installed.
2. Fan Belts: Furnish one spare fan belt for each unit installed.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 – "Systems and Equipment" and Section 7 – "Construction and Startup."

C. ASHRAE / IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE / IESNA 90.1-2004, Section 6 – "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 WARRANTY

A. Warranty: The equipment purchaser shall be provided, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and have capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Four Years from date of Substantial completion.

PART 2 PRODUCTS

2.1 FAN COIL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product in the drawing schedule or a comparable product by one of the other manufacturers specified
   1. Trane.
   2. Daikin.
   3. Or equal.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1/2-inch thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Main and Auxiliary Drain Pans: Stainless steel or Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
   1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.
   3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan-coil unit.
   4. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Washable Foam: 70 percent arrestance and 3 MERV.
   2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
   3. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Section 230900 "INSTRUMENTATION AND CONTROLS FOR HVAC" and Section 230993 "SEQUENCE AND OPERATIONS FOR HVAC CONTROLS.

K. EMCS Interface Requirements.
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at the central workstation.
   3. Provide BACnet interface for central EMCS workstation for the following functions.
      a. Adjust set points.
      b. Fan-coil-unit start, stop, and operating status.
      c. Data inquiry, including supply- and room-air temperature.

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with hangers. Vibration isolators are specified Section 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

D. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Ground equipment according to Section 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

C. Connect wiring according to Section 260519 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature setpoints.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to the Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Section 01 79 00 – Demonstration and Training.

END OF SECTION