LASELLS STEWART CENTER MECHANICAL & ROOF RENEWAL

EXHIBIT G.2 – SPECIFICATIONS VOLUME 2

Oregon State University

Construction Contracts Administration
Oregon State University
644 SW 13th Ave.
Corvallis, Oregon 97333

PN# 2240-21

bassetti architects

PROJECT MANUAL FOR:

LaSells Stewart Center Mech and Roof Renewal

OREGON STATE UNIVERSITY (OSU)

PERMIT SET

BA PROJECT NO. 2108
OSU PROJECT NO. 2240-21

VOLUME 2 - DIVISIONS 21 - 23
21 FEBRUARY 2022

PROJECT WORK SHALL BE PERFORMED IN ACCORDANCE WITH OSU CONSTRUCTION STANDARDS AS UPDATED 02/11/2020.

TABLE OF CONTENTS – VOLUME 1

*Note: Divisions 00 and 01 sections identified with an asterisk (*) are provided by Bassetti Architects; Others are sourced from the Owner.

END OF VOLUME 1

TABLE OF CONTENTS – VOLUME 2

END OF VOLUME 2

TABLE OF CONTENTS – VOLUME 3

END OF VOLUME 3

END OF TABLE OF CONTENTS

SECTION 210500 - BASIC FIRE PROTECTION MATERIALS AND METHODS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and shall include all Fire Protection Sections specified herein.

1.02 SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Compliance with all codes and standards applicable to this jurisdiction.
2. Shop Drawings for Equipment
3. Coordination Documents
4. Record Drawings
5. Start-up Service and Building Commissioning
6. Instruction, Maintenance, and O & M Manuals
7. Work associated with Delivery, Storage, and Handling of products
8. Work associated with provision of Temporary Facilities
9. Preparation of Posted Operating Instructions
10. Meeting Project Safety and Indemnity requirements
11. Proper Cleaning and Closing
12. Supplying proper Warranty information
13. Supply specified Guarantee documentation
14. Design and provision of Supports and Anchors
15. Pipe Portals
16. Access Panels and Doors
17. Identification Markers
18. Coordination of Electrical requirements for equipment provided

1.03 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide guidelines to the Contractor to provide all material and labor to modify and reorient existing system as required by architectural renovations. Exterior fire protection serving façade shall be evaluated and shall be removed if not required for new building material.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and he shall coordinate his work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the equipment, and risers and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. The Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all plumbing system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The plumbing system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply plumbing devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

G. Heat tracing shall not be used in lieu of heated valve enclosures to protect the valves and supply piping from freezing. Where used to protect branch lines, the heat tracing system shall be specifically listed for use on branch lines. Electric supervision of the heat tracing system shall provide positive confirmation that the circuit is energized. Where any portion of a system is subject to freezing and temperatures cannot be reliably maintained at or above 40°F (4°C), the system shall be installed as a dry pipe or preaction system. Comply with NFPA-13.

1.04 DESCRIPTION OF BID DOCUMENTS

A. Specifications in general, describe quality and character of materials and equipment.

1.05 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

C. Below Grade: Buried in the ground or embedded in concrete slab on ground.

D. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

E. Connect: Complete hook-up of item with required service.

F. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

G. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while

accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements. .

H. Exposed: Not installed underground or concealed.

I. Furnish: To supply equipment and products as specified.

J. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

K. Install: To erect, mount and connect complete with related accessories.

L. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

M. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

N. NRTL: Nationally Recognized Testing Laboratory, including UL and/or ETL.

O. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

P. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

Q. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner.

R. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

S. Shall: An exhortation or command to complete the specified task.

T. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

U. Supply: To purchase, procure, acquire and deliver complete with related accessories.

V. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

W. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

X. Wiring: Raceway, fittings, wire, boxes and related items.

Y. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.06 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 21 Fire Suppression sections included herein.

B. Division 02: Existing Conditions.

1. Coordination of excavation of trenches and the installation of piping on site.

C. Division 03: Concrete.

1. All concrete work for Fire Suppression Division shall be included in Division 21 under the appropriate Sections and shall include:
   a. Concrete curbs and housekeeping pads for the equipment.
   b. Thrust blocks for piping.

D. Division 07: Thermal and Moisture Protection.

1. Sealants and caulking.
2. Firestopping.

E. Division 09: Finishes:

1. Division 21 installers shall perform all painting, except where specifically stated otherwise in Division 09.

F. Division 26: Electrical is related to work of:

1. Fire protection alarms and relays.
2. Detectors and monitoring.
3. Power connections to all equipment.
4. Life safety provisions.

1.07 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 21 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:

1. NFPA Standards:
   a. NFPA 13: Standard for Installation of Sprinkler Systems (latest adopted version)

b. NFPA 14: Standard for the Installation of Standpipe and Hose Systems (latest adopted version)
c. NFPA 17: Standard for Dry Chemical Extinguishing Systems (latest adopted version)
d. NFPA 17A: Standard for Wet Chemical Extinguishing Systems (latest adopted version)
e. NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection (latest adopted version)
f. NFPA 22: Standard for Water Tanks for Private Fire Protection (latest adopted version)
g. NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances (latest adopted version)
h. NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (latest adopted version)
i. NFPA 70: National Electrical Code (latest adopted version)
j. NFPA 72: National Fire Alarm and Signaling Code (latest adopted version)
k. NFPA 80: Standard for Fire Doors and Other Opening Protectives (latest adopted version)
l. NFPA 101: Life Safety Code (latest adopted version)
m. NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems (latest adopted version)

2. Oregon Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2019 Oregon Structural Specialty Code (OSSC) based on 2012 International Building Code (IBC)
   b. 2021 Oregon Energy Efficiency Code (OEESC) based on the 2009 International Energy Conservation Code (IECC)
   c. 2019 Oregon Mechanical Specialty Code (OMSC) based on 2012 International Mechanical Code (IMC) and 2012 International Fuel Gas Code (IFGC) with State Amendments
   d. 2021 Oregon Plumbing Code (OPC) based on 2015 Uniform Plumbing Code (UPC) with State Amendments
   e. 2019 Oregon Fire Code (Based on the 2012 International Fire Code)
   f. 2017 Oregon Electric Specialty Code (Based on the 2017 National Electric Code (NEC) with State Amendments

3. Local, city, county and state codes and ordinances
4. Local and State Fire Prevention Districts.
5. Other applicable standards and references:
   a. UL and FM Compliance: Provide products, which are UL listed and FM approved.
   b. ASCE/SEI 7-10: Minimum Design Loads for Buildings and Other Structures.
   c. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
   d. SMACNA: Seismic Restraint Manual-Guidelines for Mechanical Systems.
   e. Factory Mutual Approval Guide (Product listing, only).
   f. Factory Mutual Approval Guide and FM Pamphlet #20 "Rules for Installing Sprinklers" (Product listing and project review).
   g. Underwriters Laboratories, Inc.
   h. Industrial Risk Insurance Underwriters.
   i. Owner's insurance agency.

F. Provide in accordance with appropriate referenced standards of the following:

1. ADA - Americans with Disabilities Act.

2. ANSI - American National Standards Institute.
3. ASME - American Society of Mechanical Engineers.
4. ASTM - American Society for Testing Materials.
5. AWS - American Welding Society.
6. AWWA - American Water Works Association.
7. CSA - Canadian Standards Association.
8. ETL - Electrical Testing Laboratories.
9. FM - Factory Mutual.
10. IAPMO - International Association of Plumbing and Mechanical Officials.
11. MSS - Manufacturer's Standardization Society.
12. NEMA - National Electrical Manufacturer's Association.
13. NFPA - National Fire Protection Association.
14. UL - Underwriter's Laboratories.

1.08 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner's Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Owner's Representative for a decision before proceeding.

1.09 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be aluminum or Type 304 stainless steel sheet, not less than 20 USG (0.0375"), riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data.

B. Current Models. All work shall be as follows:

1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 21, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

1. Upon request, the Owner's Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as

indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

E. Each product and/or equipment type shall be provided by one manufacturer. Mixtures of manufacturers for each product and/or equipment type are not acceptable. Example – all wet system sprinkler piping shall be supplied by one manufacturer while different piping systems may be provided by other manufacturers.

F. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

G. Welding Standards:

1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1.10 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access.

E. Coordinate equipment and materials installation with other building components.

F. Verify all dimensions by field measurements.

G. Arrange for chases, slots, and openings in other building components to allow for installations.

H. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

I. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of the work.

J. Coordinate the cutting and patching of building components to accommodate the installation of equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

K. Install fire protection services and overhead equipment to provide the maximum headroom possible.

L. Install equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

M. Coordinate the installation of materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, and other installations.

N. Coordinate connection of systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

O. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

P. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

Q. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.11 MINOR DEVIATIONS

A. The Contractor shall review the structural and architectural conditions and drawings affecting his work. It is the specific intention of this section that the contractor's scope of work shall include

1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

B. The Contractor shall study the operational requirements of each system, and shall arrange his work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work." Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

C. Advice the Owner’s Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

1.12 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.13 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner’s Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination

of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:

1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
3. Paper submittals will only be acceptable if specifically required by Division 01.
4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.14 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.

1. The shop drawings shall serve to record the coordination of the installation and location of all fire sprinkler heads, piping, HVAC equipment, ductwork, grilles, diffusers, lights, audio/video systems, electrical services and all system appurtenances.
2. The Drawings shall include all mechanical rooms and floor plans.
3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.
4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:

1. Two dimensional AutoCAD / Revit based documents:
   a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
   b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.

c. Fire protection drawings shall indicate locations of all sprinkler heads and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
e. Drawings shall incorporate all addenda items and change orders.
f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

1.15 REQUESTS FOR INFORMATION (RFIS).

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).

1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
2. RFIs shall address single questions and related issues only.
3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect and Construction Manager.
6. RFI number, numbered sequentially and unique.
7. RFI subject.
8. Specification section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the contract time or the contract sum, Contractor shall state impact in the RFI.
12. Contractor's signature.

13. Attachments: Include sketches, descriptions, measurements, photos, product data, shop drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:
    a. Incomplete RFIs or inaccurately prepared RFIs.
    b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
    c. RFIs addressing multiple unrelated issues.
    d. Requests for approval of submittals.
    e. Requests for approval of substitutions.
    f. Requests for approval of Contractor's means and methods.
    g. Requests for information already indicated in the Contract Documents.
    h. Requests for adjustments in the Contract Time or the Contract Sum.
    i. Requests for interpretation of Engineer's actions on submittals.

2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.16 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked "Record Set" at the job site at all times and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including control devices, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance.

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all "Record Set" notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and electronic media (DVD disks) labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

1.18 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.19 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.20 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner's Representative.

1.21 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

2.02 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:

1. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.
2. Manufacturers: Hilti Inc., B-Line, Anvil International, Tolco, Kin-Line, Simpson, Erico or Superstrut.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.

1. Adjustable Steel Clevis Hangers: MSS Type 1.
2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
3. U-Bolts: MSS Type 24.
4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
   a. Plate: Unguided type.
   b. Plate: Guided type.
   c. Plate: Hold-down clamp type.
5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Single Pipe Roller with Malleable Sockets: MSS Type 41.
9. Adjustable Roller Hangers: MSS Type 43.
10. Pipe Roll Stands: MSS Type 44.
11. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp or equal.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.

1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated, provide factory-fabricated building attachments of one of the following types listed.

1. Concrete Inserts: HCI-MD (for metal deck) or HCI-WF (for wood forms) cast-in anchors by Hilti Inc. or MSS Type 18 or Blue Banger Hanger by Simpson
2. Steel Brackets: One of the following for indicated loading:
   a. Light Duty: MSS Type 31.
   b. Medium Duty: MSS Type 32.
   c. Heavy Duty: MSS Type 33.
3. Horizontal Travelers: MSS Type 58.
4. Concrete Screw Anchors: Hilti Kwik HUS EZ or equal.
5. Torque-Controlled Expansion Anchor: Hilti Kwik Bolt TZ or equal.

G. Saddles and Shields (for heat traced pipe): Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
2. Insulation Protection Shields: MSS Type 40, 18" minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert.
4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and join insulation at clevis hangers and strut-mounted clamps. Klo-Shure Insulation Coupling or equal.

H. Miscellaneous Materials:

1. Metal Framing: Provide products complying with NEMA STD ML1.
2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
5. Pipe Brackets: "HoldRite" copper plated brackets. Insulate brackets attached to metal studs with felt.

2.03 SEISMIC RESTRAINT AND VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 210548 Vibration Isolation for Fire Protection Equipment or Section 210549 Seismic Restraint for Fire Protection Piping and Equipment, as applicable.

2.04 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20-gauge steel, 1" flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each concealed valve. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner's Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, or equal.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner's Representative.

2.05 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 21 Sections. Where more than a single type is specified for application, selection is at installer's option, but provide single selection for each product category. Stencils are not acceptable.

B. Plastic Pipe Markers:

1. Snap-On Type: Provide pre-printed, semi-rigid snap-on, color coded pipe markers, complying with ANSI A13.1.
2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape.
3. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

C. Underground-Type Plastic Line Markers: Provide 6" wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

D. Valve Tags:

1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve

numbers 1/2” high, and with 5/32” hole for fastener. Fill tag engraving with black enamel.

2. Plastic Laminate Valve Tags: Provide 3/32” thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32” hole for fasteners.
3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
4. Access Panel Markers: Provide 1/16” thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8” center hole to allow attachment.

E. Plastic Equipment Signs:

1. Provide 4-1/2” x 6” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering.
2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters, such as pressure, rpm, etc.

F. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., Brimar or equal.

2.06 ELECTRICAL

A. General:

1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.
2. Provide all motors for equipment specified herein. Provide motor starters, controllers, transfer switches, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
3. Set and align all motors and drives in equipment specified herein.
4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted "U" cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

B. Quality Assurance:

1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.

C. Low Voltage Control Wiring:

1. General: 14-gauge, Type THHN, color coded, installed in conduit.
2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., Southwire Co, or equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Workmanship shall be performed by licensed journeymen or master fitter and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work, unless so indicated on Drawings or approved by Owner's Representative.

3.02 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.03 INSTALLATION

A. Coordinate the work between the various Fire Protection Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Owner's Representative and at the Contractor's cost. Coordinate wall and ceiling work with the General Contractor, and his subcontractors in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

3.04 SUPPORTS AND HANGERS

A. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms.

B. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

C. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

D. Install hangers within 12 inches of every change in piping direction (only one required on either side of elbow), end of a deadend pipe run or concentrated load, and within 36 inches of every major piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

E. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

F. Support sprinkler piping independently of other piping.

G. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

H. Hanger sizing and support points shall be designed to support a minimum of five times the weight of the water-filled pipe plus 250 lbs. at each point of piping support as required by NFPA-13.

I. Hanger Spacing in accordance with following minimum schedules (other pipe/rod sizes and hanger spacings may be used in accordance with NFPA-13 or more restrictive local codes):

1. Steel Pipe:

Pipe Size	Hanger Spacing (Maximum)	Rod Size (Minimum)
Up to 1"	7 feet	3/8"
1-1/4" to 2"	10 feet	3/8"
2-1/2" to 3"	12 feet	3/8"
4" to 8”	15 feet	1/2"

2. Plastic Pipe:

Pipe Size	Hanger Spacing (Maximum)	Rod Size (Minimum)
Up to 2"	4 feet	3/8"
2-1/2" to 8”	6 feet	1/2"

J. Sloping, Air Venting, and Draining:

1. Slope all piping as specified and as indicated, true to line and grade, and free of traps and air pockets. Wet piping is not required to be sloped, but must be installed flat or with slopes to allow maintenance flushing as required by NFPA-13. Unless indicated otherwise, slope piping in the direction of flow as follows:

Service	Slope
Wet	Not required
Dry/Preaction Mains	1/4"/10'
Dry/Preaction Branches	1/2"/10'

K. Provisions for Movement:

1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.

L. Installation of Anchors:

1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

M. Equipment Supports:

1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction. Coordinate size of concrete pads and placement of anchors bolts with structural design. Anchor bolts shall be placed to maintain 6”, minimum, or greater distance from concrete pad edges.
2. Provide structural steel stands to support equipment that are not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

N. Adjusting:

1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.05 PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades they are installed when roofing is being installed.

3.06 VIBRATION CONTROL ISOLATORS

A. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

B. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.07 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping System Identification:

1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
2. Locate pipe markers as follows:
    a. Near each valve and control device.
    b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
    c. Near locations where pipes pass through walls or floors/ceilings, or other non-accessible enclosures.
    d. At access doors, manholes, and similar access points which permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.
    f. Spaced horizontally at maximum spacing of 20' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.

C. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over

buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.

D. Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:

1. Main control and operating valves, including safety devices.
2. Meters, gauges and similar units.
3. Pumps, compressors, and similar motor-driven units.
4. Tanks and pressure vessels.
5. Sprinkler and standpipe equipment.

E. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

3.08 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner's Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

END OF SECTION 210500

SECTION 211000 - FIRE PROTECTION PIPING, HEADS AND SPECIALTIES

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 210500 - Basic Fire Protection Materials and Methods, and other Sections in Division 21 specified herein.

1.02 DEFINITIONS

A. Pipe sizes used in this Section are nominal pipe size (NPS) specified in inches.

B. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA-13 for obtaining approval of AHJ (Authority Having Jurisdiction).

C. NICET - National Institute for Certification in Engineering Technologies.

D. Other definitions for fire protection systems are included in referenced NFPA Standards.

E. FM – Factory Mutual Global insurance company.

1.03 DESCRIPTION OF WORK

A. The work includes designing, providing and installing a complete and fully operable automatic sprinkler system as described in this Section of the Specification and as shown on the contract construction drawings and shall be in accordance with rules, regulations and standards as required by the authorities having jurisdiction.

1. State.
2. City.
3. Building Department.
4. Fire Prevention Division, Fire Marshal's Office.

B. Work includes but is not limited to the following:

1. Remodeling of existing systems
2. Sprinkler heads.
3. All cutting and patching.
4. Provide all pipe, fittings, sprinklers, valves, signs, flow switches, tamper switches, protective painting, test connections, drains and tests necessary to make the entire system complete and operative.
5. Coordinate with plumbing contractor for capacity of all sprinkler main, test, and auxiliary drain connections.
6. Valve tags and instruction plates shall be mounted and/or hung per local fire department requirements.
7. All required fire extinguishers.

8. All sleeves and inserts.

1.04 RELATED WORK SPECIFIED ELSEWHERE

A. Division 09: Finishes of exposed materials.

B. Section 210500: Basic Materials and Methods.

C. Division 22: Coordination with Plumbing design for location and sizes of indirect sanitary sewage drainage termination, floor sinks and/or hub drains. Fire protection designer shall provide required locations of drain locations prior to installation of plumbing work.

D. Division 26: Electrical. Coordinate for electrical wiring of detectors, flow alarm switches, tamper switches, connection to VESDA system, fire alarm bell, connection by life safety section for remote monitoring and starting of fire pump, and power to fire pumps. All electrical devices used for this system shall be compatible with the fire alarm system. Coordinate with electrical for electric fire pump motor size and emergency generator sizing.

1.05 DESIGN DESCRIPTION

A. This section of the specification combined with any of the contract drawings are intended as a guide to establish a basis of design for the systems required.

B. Contractor shall examine the existing conditions, the Architectural, Interior Design, Structural, Mechanical, Plumbing, and Electrical drawings, layout and install a complete hydraulically sized sprinkler system for all areas. Access and maintenance space shall be provided for all valves and equipment to be used.

1. System shall start 5'-0" from perimeter wall and extend throughout the building. Fire main beyond 5'-0" perimeter is provided under Division 02 work. System shall start at connection to utility main, with double detector check backflow prevention assembly, and extend throughout the building.
2. Contractor shall contact Owner’s insurance agency to incorporate insurer’s design requirements in this layout document. Factory Mutual may review layout drawings and calculations. Incorporate all of their design criteria into documents.

C. Office Areas: The main building shall be served with a wet type sprinkler system. A main riser shall be located in the stairwells with sprinkler zone valves on each floor.

D. All areas shall be sprinklered as the construction progresses, including accessible pipe chases, elevator hoistways, etc. Provide shutoff valve with tamper switch for elevator hoistways. Provide shutoff valve with tamper switch for elevator machine room. Comply with NFPA 13 and Building Code.

E. Base Building construction shall include upright heads with tees with 1” outlets for future drop in areas with no ceiling. Areas with ceilings, including finished core areas, lobbies, corridors or as noted herein shall have concealed or recessed pendant heads installed as part of the base building construction. Unfinished areas shall be provided with upright type heads. Heads will be relocated to the finished ceiling tile under the tenant improvement contract.

F. Pressure restricting devices shall be installed on any branch outlet exceeding 100 psi.

G. All electrical devices used for this system shall be compatible with the fire alarm system as referred in Division 26 work.

1.06 HYDRAULIC DESIGN

A. System shall be a straight line or gridded system per NFPA-13 with the following exceptions:

1. For all systems the design area shall be the hydraulically most demanding rectangular area.
2. Minimum pressure for any sprinkler head shall not be less than 7 psi.
3. Velocity in fire pump suction piping shall not exceed 15 feet per second.

B. Total Combined Inside & Outside Hose Allowances: Hydraulic calculations shall include an allowance for hose streams, added at the point of connection to the water supply.

C. Safety Factor: 10 psi, or 10 percent of static and residual pressure, whichever is greater.

D. Sprinkler system Occupancy Hazard Classifications shall be approved by authorities having jurisdiction:

1. Air Distribution Plenums: Light Hazard (FM HC-1).
2. Building Service Areas: Ordinary Hazard, Group 1 (FM HC-2).
3. Corridors: Light Hazard (FM HC-1).
4. Electrical Equipment Rooms: Ordinary Hazard, Group 1 (FM HC-2).
5. Fire Riser Room: Ordinary Hazard, Group 1 (FM HC-2).
6. General Storage Areas: Ordinary Hazard, Group 1 (FM HC-2).
7. Kitchens (Non-Residential): Ordinary Hazard, Group 1 (FM HC-2).
8. Laundries: Ordinary Hazard, Group 1 (FM HC-2).
9. MDF/IDF/Electronic Data Hall: Ordinary Hazard, Group 1 (FM HC-2).
10. Mechanical Equipment Rooms: Ordinary Hazard, Group 1 (FM HC-2).
11. Office and Public Areas: Light Hazard (FM HC-1).

E. Minimum Density for Automatic-Sprinkler Piping Design shall comply with the following:

1. Light Hazard Areas: Water density of 0.10 GPM per square foot calculated for an area of 1500 square feet in the most remote location.
2. Ordinary Group I Hazard Areas: Water density of 0.15 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.
3. Ordinary Group II Hazard Areas: Water density of 0.20 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.
4. Extra Group I Hazard Areas: Water density of 0.30 GPM per square foot calculated for an area of 2500 square feet in the most remote locations.
5. Extra Group II Hazard Areas: Water density of 0.40 GPM per square foot calculated for an area of 2500 square feet in the most remote locations.

F. Head spacing shall not exceed the limits described in NFPA-13.

1. Light Hazard: 225 sq.ft. (for smooth ceiling).
2. Ordinary Hazard: 130 sq.ft.
3. Extra Hazard: 100 sq.ft.

G. Maximum floor areas protected by any one sprinkler system riser:

1. Light Hazard: 52,000 sq.ft.
2. Ordinary Hazard: 52,000 sq.ft.
3. Extra Hazard: 40,000 sq.ft.

H. Flow Data: Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.

I. Other spacing requirements:

1. Maximum spacing between heads for Light Hazard and Ordinary Hazard shall not exceed 15 feet (4.6 m).
2. Maximum spacing between heads for Extra Hazard shall not exceed 12 feet (3.7 m).
3. The distance from sprinklers to walls shall not exceed 7.5 feet (2.3 m) for Light and Ordinary Hazard.
4. Sprinkler heads shall not be located closer than 4 inches (100 mm) from a wall.
5. Sprinklers shall not be spaced closer than 6 feet (1.8 m) on center.

1.07 QUALITY ASSURANCE

A. The Contractor for the fire protection installation shall be duly qualified Fire Protection Contractor, experienced and regularly engaged in the installation of fire protection systems with a license classification of C-16. Where local authorities require additional licensing of the Fire Protection Contractor, and/or workmen, such a license shall be mandatory for a prospective Contractor.

1. Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.
2. The Fire Protection contractor shall be the Engineer of Record for the automatic sprinkler and standpipe system.
3. Permits - The Fire Protection Contractor shall obtain permits for the installation or construction as required for approval and installation of the fire protection system. The Fire Protection Contractor shall submit working plans to the authorities having jurisdiction to obtain approval.

B. Welding Standards:

1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX

"Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1.08 SUBMITTALS

A. Product Data: Submit six copies of manufacturer's technical data and installation instructions for fire protection materials and products.

1. Thirty days after the awarding of contract, contractor shall submit list of manufacturer's names and model numbers for review and comment to Owner's Representative. This list shall identify any prior approved substituted items contractor wishes to use. Do not submit technical data until list has been approved.
2. Prior to construction submit for review and comment items including but not be limited to the following:
   a. Coordinated layout drawings. Lettering shall be minimum 1/8" high.
   b. Sprinklers and escutcheons - designating area of use.
   c. Valves, valve boxes, flow switches, and tamper switches.
   d. Provide Fire Marshal approval numbers for flow switches and tamper switches.
   e. Pipe, fittings, sway bracing, inserts, anchors and hangers.
   f. Inspector's test and drain station.
   g. Fire department connections.
   h. Hose valves, pressure relief valves, and pressure reducing valves.
   i. Fire pumps with performance curve.

3. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

B. Working Plans: Prepare scaled working plans for fire protection pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, and elevations and slopes of horizontal runs, wall and floor penetrations, and connections. Indicate interface between and spatial relationship to piping and adjacent equipment. Lettering shall be minimum 1/8" high.

1. Spacing of fire sprinklers shall be coordinated with lights, air conditioning outlets, sound speakers, architectural reflected ceiling plan; obstruction from light fixtures and other architectural features; and sprinkler piping shall be coordinated with HVAC ductwork & piping, plumbing, electrical conduit, cable trays and structure prior to the installation. Drawings shall be composite type including mechanical, plumbing and lighting equipment with sprinkler and sprinkler drain piping.

C. Submittal Drawings: Submit shop drawings to Agency having jurisdiction for approval bearing engineer of record stamp bearing preparer's NICET stamp. Submit six approved copies, bearing stamp and/or signature of Authority Having Jurisdiction to the Owner's Representative for review and comment.

1. Contractor shall submit sprinkler head locations to architect for approval.
2. Each calculation shall include legible schematic of system showing all hydraulic reference points.

D. Hydraulic Calculations: Prepare hydraulic calculations of fire protection systems. Submit to Authority Having Jurisdiction for approval. Submit six approved copies, bearing stamp, and/or signature of Agency having jurisdiction to Owner's Representative for review and comment.

1. Contractor shall submit published piping friction loss data from manufacturer with hydraulic calculations.

E. Certificate of Installation: Submit certificate upon completion of fire protection piping work, which indicates that work has been tested in accordance with NFPA-13, and also that system is operational, complete, and has no defects.

F. Maintenance Data: Submit maintenance data and parts lists for fire protection materials and products. Include this data, product data, shop drawings, approval drawings, approval calculation, certificate of installation, and record drawings in maintenance manual; in accordance with requirements of the General Conditions and of Division 01.

G. Operating and Maintenance Instructions: Provide the Owner with three sets of operating and maintenance instructions covering completely the operation and maintenance of sprinkler equipment and controls. Manual shall be assembled in a 3-ring binder and arranged in following sections:

1. Site Utilities: Drawings showing location, size, depth of all connections, valve boxes, manholes, etc., as installed.
2. A chart tabulating all types of pipe fittings, valves, and piping specialties installed in each system.
3. A chart tabulating all pressures, valve settings for fire department and sprinkler pressure reducing valves. Provide pressure reducing valve flow test documentation.
4. Manufacturer's brochures of all sprinkler heads.
5. Manufacturer's brochures of fire pumps, jockey pump and controllers.
6. Tamper switches and flow switches.
7. Fire Department connections.
8. Reproducible copies of approved working drawings prepared to facilitate the actual installation of ductwork and piping. Drawings shall indicate location of all concealed valves, and other apparatus.
9. Copy of NFPA-25 "Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems."
10. Approval Calculations.
11. Certificate of Installation.
12. Guarantees.
13. The Contractor is responsible for proper instruction of Owner's personnel for operation and maintenance of all material, equipment and apparatus provided.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01. Handle components carefully to prevent damage, denting, and scoring. Do not install damaged components. Damaged components shall be replaced with new components.

B. Store/protect products under provisions of Division 01. Store components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage.

1.10 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 210500 for additional warranty and Substantial Completion requirements.

C. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All products to be commercial grade, new and of the manufacturer's latest design model. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

1. All pipe, pipe fittings and valves shall be manufactured in North America, or may be import products where manufacturers are specifically identified below. Alternatives may be acceptable, but must be submitted and approved by the Owner's Representative prior to bidding.

OR

2. Upon request, the Owner's Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

B. All products to be UL listed and/or FM approved, except for items, which are not required to be listed by code.

C. All products shall be delivered and stored in original containers. Containers shall be clearly marked or stamped with manufacturer's name and rating.

D. The following items to be included but specified under Section 210500: Basic Fire Protection Materials and Methods.

1. Hangers and supports.
2. Escutcheons plates, flashings and sleeves.
3. Access panel and doors.
4. Identification markers and signs.
5. Expansion compensators and flexible connectors.
6. Anchors, and seismic restraints.
7. Excavation and backfill.

2.02 SPRINKLER HEADS - GENERAL

A. Sprinkler heads shall be regular automatic closed-type heads of ordinary degree temperature rating except that sprinkler heads installed near the heating equipment or in special occupancy areas shall be of the temperature rating as described in NFPA-13.

B. Provide quick response heads in all new light hazard occupancies.

C. For existing sprinkler systems, provide sprinkler heads with response type to match existing type unless otherwise noted.

D. Provide corrosion-resistant sprinkler heads where they are exposed to weather, moisture or corrosive vapors.

E. The Contractor shall furnish spare heads. The heads shall be packed in a suitable container and shall be representative of, and in proportion to, the number of each type and temperature rating head installed. In addition to the spare heads, the contractor shall furnish not less than two special sprinkler head wrenches. Refer to NFPA-13 section; "Stock of Spare Heads".

F. Provide escutcheon and minimum 1/4” clearance around penetrations through suspended ceilings per ASCE requirements.

G. Sprinkler heads installed shall be upright or pendent, as conditions require, and shall be of the following type and finish for the areas designated. Unless otherwise specified, sprinklers shall be small frame type, center bulb capsule for finished areas, fusible link for unfinished areas, and 1/2" orifice. Extended coverage heads not allowed in unfinished areas except garages.

H. Sprinkler heads shall have a standard or large orifice K-Factor of 5.6 or 8.0. Sprinkler heads shall be UL Listed and FM Approved.

I. Manufacturers: Viking, Tyco, Anvil, Reliable, Globe, Victaulic, Venus or equal. Viking models shown as basis of design.

J. Sprinkler head requirements for each area as follows:

BUILDING AREA	SPRINKLER HEAD STYLE	SPRINKLER HEAD FINISH	ESCUTCHEON FINISH	TEMPERATURE RATING (°F)
Unfinished Space, Exposed Ceiling Retail, Exposed Ceiling Office, Parking Structure, Mechanical Rooms	Upright/Pendant	Brass	None	155°F
Electrical, Switchgear, IDF/MDF, Telephone Equipment, and Computer Equipment Rooms without finished ceilings.	Upright	Brass	None	286°F
Finished Ceilings	Semi-recessed Pendant	White	White	155°F
Finished Ceilings in Conference Rooms and Lobbies	Concealed Pendant	Brass	White Cover Plate	155°F
Soffit & Sidewall	Flush Sidewall	White	White	155°F

Exterior Balconies & Overhangs	Dry Sidewall	Brass	Chrome	175°F
Grease Exhaust Duct	Standard Pendant	Electroless Nickel PTFE (ENT)	None	360°F

K. Quick response sprinkler heads for dry systems, preaction systems and areas subject to freezing:

1. Upright in exposed areas: Viking #VK184 (K Factor: 5.6)
2. Pendent in exposed areas with no ceilings. Viking #VK186 (K Factor: 5.6)
3. Pendent in exposed areas with ceilings. Viking #VK196 (K Factor: 5.6)
4. Sidewall: Viking #VK188 (K Factor: 5.6), #VK284 or #VK288 or #VK292 (K Factor: 8.0)
5. Sidewall for extra hazard Standard Coverage Viking #VK2923 (K Factor: 5.6)
6. Standard Coverage Pendent in exposed area with ceiling Standard Coverage Flush Pendent Viking #VK482 (K Factor: 5.6)

2.03 PIPE AND FITTINGS - ABOVE GROUND

A. General: The piping products listed below by manufacturer's name and model numbers are the only acceptable materials listed for this project. Substitutions of pipe must be submitted and approved in writing by the Owner's Representative prior to bid.

B. Piping and fittings shall be new and clean prior to installation. Piping or fittings that show substantial rust or breaks in coating will be removed and replaced.

C. Steel Pipe and Fittings for wet systems:

1. All steel pipe material shall be corrosion-resistant with a black enamel coating or other corrosion-resistant coating with a corrosion resistance ratio (CRR) of 1 or more.
2. Schedule 40, Standard Weight, Black-Steel Pipe: ASTM A53/A53M. Pipe ends may be factory or field formed to match joining method.
3. Schedule 30, Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30. Pipe ends may be factory or field formed to match joining method.
4. Thinwall Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
5. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 for sizes NPS 5 (DN 125) and smaller; and NFPA-13 specified wall thickness for sizes NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
6. Stainless Steel Pipe, Schedule 10S or 40S: Manufactured and installed per ASTM A312/312M.
7. Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
8. Uncoated-Steel Couplings: ASTM A865/A865M, threaded.
9. Malleable Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
10. Cast Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
11. Malleable- or Ductile-Iron Unions: UL 860.
12. Cast-Iron Flanges: ASME 16.1, Class 125.

13. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
    a. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
    b. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    c. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
    d. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
    e. Mechanical type flange fittings or joint restraint systems are not acceptable.

14. Steel Welded Fittings: Comply with ASTM A234/A234M, ASME B16.9, ASME B16.25, and ASME B16.11.
    a. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
    b. Shop fabricated Bonney Forge "Weldolet" or "Thredolet" type fittings may be used in lieu of tee fittings, but field (site) welding will not be permitted.

15. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175-psig (1200-kPA) minimum, and as required by the design.
    b. Painted or Uncoated Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
    c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
    d. Grooved joint couplings shall consist of two ASTM A 536 ductile iron housings, pressure-responsive, synthetic rubber gasket, and plated steel bolts and nuts.
        1) Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA 13. Tongue and recess rigid type couplings shall only be permitted if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufacturer's latest recommendations.
    e. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
    f. Use rigid type couplings where installation flexibility is not required.
    g. Mechanical Couplings: Victaulic grooved couplings style 07, 75 or 77, or equal by Gruvlok.

D. Copper Tube and Fittings for wet systems

1. Solder or brazed joints are NOT allowed for any copper tubing or piping systems.
2. Mechanical pressed or grooved type joints shall be used for copper tubing and piping joints and fittings.
3. Seamless copper tube, pipe sizes up to 8":
    a. ASTM B88, Type K or L, hard temper. Type M is not allowed.
    a. Manufacturers: Mueller Streamline, Cerro Flow Products, or equal.

4. Mechanical Grooved Couplings and Fittings:
    a. Standard: UL 213
    b. Grooved-End Copper Fittings: ASTM B76 copper tube or ASTM B584 bronze castings.
    c. Manufacturers: Victaulic, Anvil, or equal.

5. Mechanical Pressure-Seal-Joint Couplings and Fittings:
    a. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
    b. Minimum 200 psig working pressure.
    c. Manufacturer: Viega or equal.

E. Dry Standpipe, Dry Sprinkler and Preaction Sprinkler Piping and Fittings:

1. All steel pipe material shall be corrosion-resistant with a black enamel coating or other corrosion-resistant coating with a corrosion resistance ratio (CRR) of 1 or more.
2. Schedule 40, Standard Weight Black-Steel Pipe: ASTM A53/A53M. Other pipe materials will not be accepted for these applications.
3. Pipe ends may be factory or field formed to match joining method.
4. Rolled groove fittings are not allowed in a dry or preaction sprinkler system per Factory Mutual.

F. Flexible sprinkler connector for ceiling adjustability, seismic accommodation, and ductwork sprinkler applications. Stainless steel flexible braided tubing, Factory Mutual approved, and compatible with FM and UL sprinkler heads. Rated working pressure to 175 psi. Hose lengths up to 72" maximum. Manufacturers: Flexhead (Anvil), Viking, Victaulic #VicFlex, or equal.

G. Dielectric Fittings:

1. Dielectric Waterways/Nipples:
    a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
    b. Comply with standard IAPMO PS 66.
    c. Electroplated steel waterway/nipple complying with ASTM F1545 or ASTM F492.
    d. Pressure Rating: 300 psig (2070 kPa) at 225°F (107°C).
    e. End Connections: Male threaded or grooved.
    f. Lining: Inert and noncorrosive, propylene.
    g. Manufacturers: Mifab #MI-DE Series, Victaulic #Series 647, or equal.

2. Dielectric Flanges:
    a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
    b. Comply with standard ASSE 1079.
    c. Factory-fabricated, bolted, companion-flange assembly.
    d. Pressure Rating: 125 psig (860 kPa) minimum at 180°F (82°C).
    e. End Connections: Solder or brazed joint copper alloy and threaded ferrous; or threaded solder-joint copper alloy and threaded ferrous.
    f. Dielectric-Flange Insulating Kits:
        1) Nonconducting materials for field assembly of companion flanges.
        2) Gasket: Neoprene or phenolic.
        3) Bolt Sleeves: Phenolic or polyethylene.
        4) Washers: Phenolic with steel backing washers.
    g. Manufacturers: Watts #LF3100 Series or equal.

H. Piping and Fittings – Not Allowed:

1. Galvanized steel piping is not allowed due to corrosion potential. However, with pre-approval prior to bid, the use of galvanized steel in a dry or preaction system may be proposed when connected to a nitrogen source as a supervisory gas.
2. Copper pipe with soldered or brazed joints and fittings.
3. Pipe that is lighter gauge than Schedule 30 steel with threaded fittings is not allowed.
4. Schedule 5 piping and fittings are not allowed.
5. Threadable lightwall pipe is not allowed.
6. Mechanical "gripping teeth" type fittings are not allowed.
7. Mechanical "clamping" type tee fittings are not allowed.
8. Quick disconnect, boltless, snap-joint, field drilling or welding of any main or branch lines, and any device specifically prohibited by the local authority having jurisdiction is not allowed.
9. Unions are not allowed for any size pipe.
10. Plain end fittings are not allowed.

2.04 PIPE AND FITTINGS - UNDERGROUND

A. Ductile Iron Pipe and Fittings, Class 52 or better (outside of building envelope)

1. Ductile iron pipe, pressure class 350 psi, compliant with ANSI/AWWA C151/A21.51. Fittings compliant with ANSI/AWWA C110/A21.10.
2. Mechanical or Tyton joint fittings. Rubber gasket shall comply with ANSI/AWWA C111/A21.11.
3. External pipe coating shall be asphaltic coating per ANSI/AWWA C151/A21.51 and ANSI/AWWA C110/A21.10 for fittings. Or, field wrapped with double layers of 2" wide, 20 mil vinyl tape, with 50% overlap.
4. Interior pipe shall be cement-mortar lined in accordance with ANSI/AWWA C104/A21.14.
5. Piping shall be field wrapped in approved 8-mil polyethylene encasement per AWWA/ANSI C105/A21.5. Method A and B use polyethylene tubes and Method C uses polyethylene sheets.
6. Manufacturer: United States Pipe and Foundry, Pacific States Cast Iron Pipe Co., McWane Cast Iron Pipe Co., or equal.

B. Polyvinyl Chloride (PVC) Plastic Pipe (outside of building envelope):

1. Pipe and fittings: Pipe shall conform to AWWA C900 and shall be plain end or gasket bell-end, pressure Class 150 with cast-iron-pipe-equivalent OD. Fittings shall be gray-iron or ductile-iron conforming to AWWA C110, and shall have cement lining conforming to AWWA C104, standard thickness.
2. Joints and Jointing Material: Joints for pipe shall be push on joints as specified in ASTM D3139. Joints between pipe and metal fittings, valves, and other accessories shall be push on joints as specified in ASTM D3139 or shall be compression type joints / mechanical joints as respectively specified in ASTM D3139 and AWWA C111. Provide each joint connection with an elastomeric gasket suitable for bell or coupling or push-on joints with which it is to be used.
3. Transition from PVC to ductile iron pipe shall occur a minimum of 5 feet from building.

C. All underground piping for fire mains shall be installed, clamped, anchored, flushed and hydrostatically pressure tested according to the requirements of the authorities and/or Agencies

Having Jurisdiction, and NFPA-13, NFPA-24 and Factory Mutual Handbook of Industrial Loss Prevention.

D. Anchor underground riser stub to nearest underground connection by means of rodding. Retaining glands with setscrews above grade are not allowed.

2.05 RODS AND CLAMPS

A. Socket clamps shall be stainless steel; four bolt type, equipped with stainless steel socket clamp washers and nuts. Manufacturers: Grinnell Fig. 595 and 594, Elcen Fig. 37 and 37X, or equal.

B. Rods shall be stainless steel, 3/4" diameter.

2.06 VALVING

A. 2" or Smaller:

1. Control Valve: OS&Y rising stem type gate or globe valve, bronze body, bonnet and disc, copper alloy stem, threaded ends, 175 psig WOG min. Provide with tamper switch.
2. Check Valve: Swing check type with bronze body, cap and disc, threaded ends, 175 psig WOG min.
3. Drip Valve: 3/4", cast brass automatic ball drip type, threaded ends, 175 psig WOG min.
4. Testing Valve: 1-1/4", test and drain, sight glass, 1/2" test orifice, lever operated, 300 psi WOG. Drain to mop sink or drain riser.
5. Main Drain Valve: 2", angle gate valve, bronze body, copper alloy stem, threaded ends, 175 psi WOG. Drain to mop sink or drain riser.
6. Manufacturer: Grinnell, Victaulic, Stockham, Milwaukee, Mueller, Nibco, United Brass Works, Kennedy, Elkart or AGF.

B. Manufactures: American Darling, Clow, Dresser, U.S. Pipe, or equal.

2.07 VALVE BOXES

A. Cast iron valve boxes for shutoff valves buried in ground shall be complete with bellbottoms, extension piece, top and cover. Boxes shall be suitable for the types of valves with which they are used. All valve boxes shall have a concrete collar flush with grade.

B. Lids shall have the applicable letters embossed upon the top surface. Tagging shall match existing lids.

C. Manufacturers: Tyler, ITT Grinnell, or equal.

2.08 PRESSURE REDUCING VALVES

A. Sprinkler System: Rough bronze body with red enameled hand wheel with integral check valve of the pressure reducing type. Outlet pressure shall not exceed 165 psig at maximum system pressures. Pressure settings to be field adjustable.

1. Manufacturers: Zurn #Z-3004

B. Fire Service: 150 class pressure rating, cast iron body with brass main valve trim, control system cast bronze with stainless steel trim

1. Manufacturers: Cla-Val #90-21UL or equal.

2.09 PRESSURE RELIEF VALVE

A. Provide 3/4" pressure relief valve on discharge side of Sprinkler system pressure reducing valve. Set to a maximum of 175 psi.

1. Manufacturers: Zurn #P1000A or equal.

2.10 INTEGRAL INSPECTORS ALARM TEST AND SYSTEM DRAIN

A. Combination system alarm test module with drain and visible orifice insert/sight glass for testing system alarm:

1. Threaded or grooved inlet and outlet connections.
2. Bronze body.
3. Malleable iron hand wheel.
4. EPDM valve seats.
5. Maximum working pressure 300 psi.
6. Test port orifice sizes: K5.6 or K8.0.
7. FM listed.
8. 1/2” pressure relief valve, 175 psi rating.
9. Alarm test module manufacturer: Victaulic TestMaster II #Serie 720 or equal.
10. Pressure relief valve manufacturer: Watts Regulator #FP 53L or equal

B. Water pressure gauge, range 0-300, in 5 psig increments, brass case, 3-1/2" diameter (minimum), 1/4" NPT male pipe connection, UL listed. Locate pressure gage on riser per code. Manufacturer: Star Sprinkler, Ashcroft or equal.

C. Pressure gauge test valve, brass 1/4" screwed ends, 300 psig WOG. Manufacturer: United or equal.

D. All relief, main, auxiliary and equipment drain piping shall be routed separately to floor sink(s) or other approved locations. Coordinate with plumbing design for location of floor sinks or other approved drain locations.

2.11 MANUAL BRANCH LINE AIR VENT

A. Pressure Rating: 300 psig (2070 kPa) minimum.

B. Manual Air Vent Valve:

1. Body Material: Forged brass body.
2. Components: Integrated ball valve, stainless steel strainer, threaded cap with lanyard, polypropylene float.
3. Inlet Size: 1/2-inch NPT.
4. Outlet Size: 1/2-inch NPT.

C. Manufacturer: AGF Manufacturing PURGEnVENT #7910MAV or equal.

PART 3 - EXECUTION

3.01 GENERAL

A. This system to be installed by an experienced firm regularly engaged in the installation of automatic sprinkler system as specified by the requirements of the Specifications.

3.02 PERFORMANCE OF WORK

A. Examine areas and conditions under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings and in accordance with NFPA 13, 14, 20 and 24.

B. Work to start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed.

C. Coordinate with other trades as necessary to properly interface components of the sprinkler system.

D. Follow manufacturer's directions and recommendations in all cases.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.03 TEMPORARY FIRE PROTECTION

A. Provide all temporary valving, piping, Siamese connections and other components as directed by the fire agency office during all phases of construction.

3.04 INSTALLATION-GENERAL

A. Fire protection system shall be installed in accordance with the approved Drawings. The finished ceiling is not to be erected until all fire protection piping has been installed, tested, and inspected. Sprinkler heads located in the electrical equipment, elevator machine, or similar rooms shall be furnished with deflectors to prevent water spray on equipment.

B. Before connection to the overhead piping, all underground piping shall be flushed with water flowing at velocity and quantity required by the installation standards specified above in this Section of the Specifications.

C. The arrangement of all pipes shall conform to all architectural requirements and field conditions, shall be as straight and direct as possible, forming right angles or parallel lines with building walls and other pipes, and shall be neatly spaced. Offsets will be permitted only where required to permit the pipes to follow the walls. Standard fittings shall be used for offsets. All risers shall be erected plumb and true, shall be parallel with the walls and other pipes, and shall be neatly spaced. All work shall be coordinated with HVAC, Plumbing, Electrical and Structural

work in order to avoid interference and unnecessary cutting of floors or walls. All underground or concealed work shall be inspected before the construction is closed up.

D. All sprinkler heads to be installed in ceilings throughout the scope of work building as listed in Part 2 sections. All areas without ceilings shall have rough brass upright or pendent heads.

E. Sprinkler heads in all finished areas are to be installed on a true axis line in both directions, with maximum deviation from the axis line of 1/2-inch plus or minus and shall be plus or minus 1" within center of tile. At the completion of the installation, if any heads are found to exceed the above-mentioned tolerance, they shall be removed and reinstalled.

F. No pipes or other apparatus shall be installed so as to interfere in any way with full swing of doors.

G. The arrangement, positions, and connections of pipes, drains, valves, etc., shall be as required by NFPA-13 for all areas requiring sprinklers. At all low points provide drains and provide drains or capped tees fittings at isolated low points in the piping system. However, the right is reserved by the Owner's Representative to change the location of any item to accommodate conditions, which may arise during progress of the work, without additional compensation for such changes provided that no additional heads are required prior to the installation of the work.

H. Where required, piping shall be installed concealed in building construction, or though steel beams, to obtain adequate head room.

I. All pipe throughout the job shall be reamed smooth before being installed. Pipe shall not be split, bent, flattened, or otherwise injured either before or during installation.

J. Provide protective pans under pipes passing over high voltage electrical bus duct or switchgear equipment. The pan shall be constructed of 22-gauge black iron with a 6-inch lip, the corners being welded to make the pans watertight. Each pan shall be given two coats of gray primer paint and shall be supported by pipe hangers. The pan shall drain clear of the bus duct or switchgear.

K. All pipe interiors shall be thoroughly cleaned of foreign matter before installation, and shall be kept clean during installation by plugging or other approved means. Piping shall be covered with waterproof plastic sheeting during storage. Piping that shows signs of rusting will be removed from job site and replaced.

L. Field Connections: Any modifications to system required by field conditions, physical equipment changes or compliance with code regulations shall be made promptly without cost to Owner.

M. Interference: No piping or sprinkler devices shall interfere with the operations of any door, window, or mechanical and/or electrical systems. No part of this system shall visibly installed in the physical parameter of any window.

N. Threaded Pipe: Threads shall be clean cut, standard and tapered. Threads shall be made up using flaked graphite and lubricating oil, piping compound or Teflon tape applied to the male threads only.

O. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the

grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by the same manufacturer. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

P. Keep all pipe and other openings closed to prevent entry of foreign matter. Cover all equipment and apparatus to protect against dirt, water, chemical or mechanical damage, before and during construction period. Restore to original condition all apparatus and equipment damaged prior to final acceptance, including restoration of damaged shop coats of paint.

Q. Location of sprinkler piping is critical.

1. Where ceiling space is at a minimum under beams location of ductwork takes precedence, coordinate accordingly.
2. Include in base bid, multiple coordination meetings, as required with Owner's Representative for coordination of sprinkler pipe routing, at no additional cost to the Owner.

3.05 MAIN DRAIN TEST CONNECTIONS

A. Provide and install all drain piping associated with fire protection systems as required by NFPA-13, Chapter 8. Minimum drain riser size shall be 2-1/2" diameter, or larger, as required by quantity of connections to riser.

B. Coordinate location of floor sinks and sizing with plumbing design prior to installation of fire protection or plumbing piping. Fire protection contractor will be responsible for any revisions to other trades due to lack of fire protection coordination.

C. Drain piping shall be provided and installed by fire protection installer. Drains shall discharge outside or to a drain connection capable of handling the flow of the drain. Where possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage.

D. Main drain test connections shall be provided at locations that will permit flow test of water supplies and connections.

E. Where drain connections for floor control valves are tied into a common drain riser, the drain riser shall be one pipe size larger downstream of each size drain connection typing into it.

F. Where exposed drain pipes terminate provide turned-down elbow and terminate with a minimum air gap of two times the drain pipe diameter.

G. Drain pipes shall be arranged to avoid exposing any of the water-filled portion of the sprinkler system to freezing conditions.

H. Provisions should include vents at the top of drain riser including a check valve to allow air into the drain riser.

3.06 SLEEVES AND FLASHINGS

A. Wherever pipes are exposed and pass through walls, floors, partitions or ceilings, they shall be fitted with chromium plated steel escutcheons held in place with setscrews. Care shall be taken to protect the escutcheons during the course of construction.

B. Penetrations through fire rated walls and floors shall be sealed with listed mastic of similar fire rating.

3.07 HANGERS, INSERTS, SUPPORTS, AND SWAY BRACING

A. Hangers and supports shall be installed per NFPA-13 sections on Hangers and Protection of Piping Against Damage Where Subject to Earthquake. Provide restraint from movement at end sprinkler on branch line per NFPA-13.

B. Bending of threaded hanger rod is not allowed. Powder driven anchor pins in concrete are not allowed.

C. Upgrade existing end sprinklers on branch line with new restraint from movement device.

3.08 SAFETY TESTING & VERIFICATION

A. Flush, test, and inspect sprinkler piping systems according to NFPA-13 Chapter "System Acceptance" and refer to Factory Mutual FMDS0201 for guidelines on corrosion in sprinkler systems.

1. Chemical cleaning or water treatment shall not be provided. The introduction of a treatment solution into the sprinkler piping network with dead-end pipe runs and pendent drops can result in a large variation of chemical concentrations which can accelerate corrosion and growth of microorganisms. Flushing of the system until water is clear and venting all air is the recommended method for maintaining sprinkler piping.

B. Provide NFPA-13 Contractor's Material & Test Certificate Form 85A for above ground piping and Form 85B for underground piping.

C. Provide manpower to test the function and performance of all Life Safety System components and devices per floor and per zone basis in accordance with the local requirements.

3.09 IDENTIFICATION

A. In addition to the requirements of Section 210500, provide engraved pipe markers every 20 feet, once in every room, and at each building level traversed, minimum. Text shall include riser and/or zone numbers to align with drawings and fire alarm panel.

B. Provide hydraulic design data nameplates (engraved text) on the riser of each sprinkler system in accordance with NFPA-13

C. Equipment such as valves, drains, etc., shall be provided with signs that identify type of equipment and service. The tag shall be securely fastened to the handle or spindle of the valve by a brass chain. Furnish four schedules of valves so tagged. There shall also be furnished

four diagrammatic charts showing schematically the complete sprinkler system with major control valves and numbers thereof. One set of Schedules and charts shall be mounted in glazed frames located where directed.

3.10 AS-BUILT RECORD DRAWINGS AND CERTIFICATION

A. As-built Record Drawings are to be kept up-to-date and the Master Copy kept at the job site. Prior to final acceptance of work being approved, these drawings are to be turned over to the Owner's Representative for approval.

B. Written certification from the insuring agents, and authorities having jurisdiction that the tests were satisfactory.

C. After installation is complete and tests satisfactorily approved, deliver test certificates and approval by the local Fire Authorities and the insurance company to the Owner’s Representative. Final acceptance of sprinkler/standpipe system by Owner's Representative shall be contingent upon receipt of certificate and approval from authorities having jurisdiction and for the delivery of final Record Drawings.

3.11 INSPECTION, TESTING, AND MAINTENANCE

A. Where steel pipe is used in dry pipe and preaction systems, it shall be assumed that the water supplies and environmental conditions contribute to unusual corrosive properties.

B. A corrosion protection plan shall be developed to address steel piping corrosion in accordance with NFPA-13 and NFPA-25.

C. Sprinkler piping and fittings shall be inspected annually by the Owner’s Representative for signs of corrosion, leakage, and physical damage, in accordance with NFPA-25.

D. Inspection, testing, and maintenance activities shall be followed to determine that components are free of corrosion, foreign material, physical damage, tampering, or other conditions that adversely affect system operation.

E. An internal corrosion evaluation of system piping shall be conducted at intervals not to exceed five (5) years.

F. The evaluation shall include an internal inspection of the piping condition near the sprinkler riser and the opening of the flushing connection on a system main.

END OF SECTION 211000

SECTION 220500 - BASIC PLUMBING MATERIALS AND METHODS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and all Plumbing Sections specified herein.

1.02 SCOPE OF THIS SECTION

A. Work to be furnished and installed under this Section shall include, but not necessarily be limited to, the following:

1. Compliance with all codes and standards applicable to this jurisdiction.
2. Shop Drawings for Equipment
3. Coordination Documents
4. Record drawings
5. Start-up and commissioning service
6. Instruction, Training, and Operations & Maintenance Manuals
7. Work associated with delivery, storage, and handling of products
8. Work associated with provision of temporary facilities
9. Preparation of posted operating instructions
10. Meeting project safety and indemnity requirements
11. Proper cleaning and closing
12. Supplying proper Warranty information
13. Supply specified Guarantee documentation
14. Design and provision of supports and anchors
15. Design and provision of seismic restraints
16. Design and provision of vibration isolation
17. Through-penetration and membrane penetration firestop assemblies
18. Hangers and supports
19. Pipe portals
20. Pipe stands
21. Equipment supports
22. Access panels and doors
23. Roof flashings
24. Drains
25. Miscellaneous fixtures
26. Identification markers, equipment labels, pipe labels, valve tags, warning signs.
27. Coordination of electrical requirements for equipment provided

1.03 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to include all material and labor to install complete plumbing systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate the work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, and pipe routing and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and/or site systems, existing utilities and services have been indicated on the drawings to the extent possible based on available record drawings. The Contractor shall thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all plumbing system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The plumbing system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply plumbing devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

G. Refer to Basis of Design on drawings. Systems as specified under this section shall include, but not necessarily be limited to, the following:

1. Connection to site utilities between two (2) and five (5) feet from the building as defined by local jurisdiction. Coordinate with the Civil Engineering design and plans.
2. Connection of all waste, vent, and water piping to all plumbing fixtures, sinks, toilets, drinking fountains, sinks, water dispensers, drains and mechanical equipment.

1.04 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer's data, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:

1. Supports and anchors
2. Access panels and doors
3. Identification markers, labels and tags
4. Pipe portals
5. Plumbing specialties
6. Cleanouts
7. Drains
8. Roof flashing

B. Contractor shall submit a letter that all products used in the plumbing system are certified for use in the State and Municipality of the project site.

1.05 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:

1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and details of installation.
2. Before proceeding with work check and verify all dimensions.
3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
4. Make adjustments that may be necessary or requested, to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
5. Verify exact location and elevation of existing piping, ductwork, conduits and structure and coordinate to accommodate installation of new work as indicated on the drawings.
6. If any part of Specifications or Drawings appears unclear or contradictory, apply to the Owner's Representative for interpretation and decision as early as possible, including during bidding period.

1.06 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

C. Below Grade: Buried in the ground or embedded in concrete slab on ground.

D. Building Drain: That part of the lowest piping of a drainage system that receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning 2 feet (610 mm) to 5 feet (1,524 mm) outside the building wall.

E. Building Sewer: That part of the horizontal piping of a drainage system that extends from the end of the building drain and that receives the discharge of the building drain and conveys it to a public sewer, private sewer, private sewage disposal system, or other point of disposal.

F. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

G. Connect: Complete hook-up of item with required service.

H. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

I. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements. .

J. Exposed: Not installed underground or concealed.

K. Furnish: To supply equipment and products as specified.

L. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

M. Install: To erect, mount and connect complete with related accessories.

N. Lead Free: Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining "weighted average".

O. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

P. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

Q. Noncombustible Material: A noncombustible material is a substance that will not ignite, burn, support combustion, or release flammable vapors when subject to fire or heat in compliance with ASTM E136 Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C. Examples of noncombustible materials include the following, but confirm compliance in manufacturer literature:

1. Portland cement concrete, concrete, gypsum concrete (normally used in drywall or poured gypsum floor toppings), Portland cement stucco, Portland cement plaster, and gypsum plaster, gypsum wall board (sheetrock), and Type X gypsum wall board.
2. Brick masonry, concrete block masonry, and ceramic tiles.
3. Steel, stainless steel, galvanized steel, and other metals, except aluminum (aluminum is classified as limited-combustible), magnesium and magnesium alloys.
4. Sheet glass, block glass, and uncoated glass fibers.
5. Mineral wool and rock wool.

R. NRTL: Nationally Recognized Testing Laboratory, including UL, CSA and/or ETL.

S. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

T. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

U. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

V. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

W. Shall: An exhortation or command to complete the specified task.

X. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

Y. Supply: To purchase, procure, acquire and deliver complete with related accessories.

Z. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

AA. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

BB. Wiring: Raceway, fittings, wire, boxes and related items.

CC. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.07 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 22 Plumbing sections included herein.

B. Division 01: General Requirements

1. Including commissioning requirements.

C. Division 07: Thermal and Moisture Protection.

1. Flashing and sheet metal.
2. Sealants and caulking.
3. Firestopping.

D. Division 09: Finishes.

1. Division 22 installers shall perform all painting, except where specifically stated otherwise in Division 09.
2. Painting of all exposed steel, piping, insulation, equipment, and materials.
3. All exposed gas piping located exterior to the building and as required by Authority Having Jurisdiction.

E. Division 21: Fire Suppression.

1. Fire protection contractor to provide drain piping from fire suppression risers, inspector test locations and auxiliary drain locations to approved termination outside the building or other approved locations per NFPA-13.
2. Coordinate required indirect plumbing drain location(s), floor sinks and/or hub drains, with fire protection design. Provide minimum 3” sanitary sewer to serve riser drainage, or as shown on the drawings.

F. Division 23: HVAC.

1. Drain inlets and sanitary sewer piping to serve all condensate and equipment drainage from mechanical equipment.
2. Coordinate plumbing piping and drain locations with HVAC drawings.
3. Domestic water makeup water piping, valves and backflow prevention devices to serve mechanical equipment.

1.08 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 22 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:

1. Oregon Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2019 Oregon Structural Specialty Code (OSSC) based on 2018 International Building Code (IBC)
   b. 2021 Oregon Energy Efficiency Code (OEESC) based on the 2018 International Energy Conservation Code (IECC)
   c. 2019 Oregon Mechanical Specialty Code (OMSC) based on 2018 International Mechanical Code (IMC) and 2018 International Fuel Gas Code (IFGC) with State Amendments
   d. 2021 Oregon Plumbing Code (OPC) based on 2021 Uniform Plumbing Code (UPC) with State Amendments
   e. 2021 Oregon Fire Code (Based on the 2021 International Fire Code)
   f. 2017 Oregon Electric Specialty Code (Based on the 2017 National Electric Code (NEC) with State Amendments
2. Local jurisdiction codes and amendments
3. Local utility requirements for water, sewer and gas provisions as appropriate
4. State Fire Marshal Office
5. Health Department
6. State Administrative Codes

F. All accessible plumbing work shall comply with the Americans with Disabilities Act (ADA)and local amendments. Compliance requirements applicable to plumbing work includes, but is not limited to, the following ADA requirements:

1. Section 309: Operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be five (5) pounds maximum.
2. Section 609: No plumbing fixtures or valves may impede on grab bar clearances. Grab bars are installed in a horizontal position between 33" and 36" above the finish floor to the top of the grab bar. The clear space between the wall and the grab bar shall be 1-1/2" minimum with no obstructions created by valves, fittings or controls. The space between the grab bar and projecting objects above shall be 12" minimum. The space between the grab bar and projecting objects below shall be 1-1/2" minimum.
3. Section 604.4: The seat height of a water closet above the finish floor shall be 17" minimum and 19" maximum measured to the top of the seat. Seats shall not be sprung to return to a lifted position. A water closet in a toilet room for a single occupant accessed only through a private office and not for common use or public use shall not be required to comply. In residential dwelling units the height of water closets shall be permitted to be 15" minimum and 19" maximum above the finish floor measured to the top of the seat.
4. Section 605.2: Urinal shall be a stall-type or wall-hung type with the rim 17" maximum above the finish floor or ground. Urinals shall be 13-1/2" deep minimum.
5. Section 606.3: Lavatories and sinks shall be installed with the front of the higher of the rim or counter surface 34" maximum above the finish floor.
6. Section 606.4: Hand-operated metering faucets shall remain open for 10 seconds minimum.
7. Section 606.5: Water supply and drain pipes under lavatories and sinks shall be insulated or otherwise configured to protect against contact. There shall be no sharp or abrasive surfaces under lavatories and sinks.
8. Section 602: Drinking fountain spout height shall be 36" maximum above the finish floor. The spout shall provide a flow of water 4" high minimum and shall be located 5" maximum from the front of the unit.
9. Section 608.6: A shower spray unit with a hose 59" minimum that can be used both as a fixed-position shower head and as hand-held shower. The shower spray unit shall have an on/off control with a non-positive shut-off. The shower unit shall not obstruct grad bar clearances. Shower spray units shall deliver water that does not exceed 120°F maximum.
10. Section 608.7: Thresholds in roll-in type shower compartments shall be 1/2" high maximum.

G. Provide in accordance with appropriate referenced standards of the following:

1. ADA - Americans with Disabilities Act.
2. ADC - Air Diffuser Council.
3. ANSI - American National Standards Institute.
4. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers.
5. ASME - American Society of Mechanical Engineers.
6. ASSE - American Society of Sanitary Engineers.
7. ASTM - American Society for Testing Materials.
8. AWS - American Welding Society.
9. AWWA - American Water Works Association.
10. CISPI - Cast Iron Soil Pipe Institute.
11. CSA - Canadian Standards Association.

12. ETL - Electrical Testing Laboratories.
13. FM - Factory Mutual.
14. IAPMO - International Association of Plumbing and Mechanical Officials.
15. MSS - Manufacturer's Standardization Society.
16. NEMA - National Electrical Manufacturer's Association.
17. NFPA - National Fire Protection Association.
18. PDI - Plumbing and Drainage Institute.
19. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
20. UL - Underwriter's Laboratories.

H. Provide compliance in accordance with the following referenced standard which applies to general system compliance in contrast to specific equipment standards referenced elsewhere:

1. UL-2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces. This is applicable to spaces above suspended ceilings and below raised floors.

1.09 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner's Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Owner's Representative for a decision before proceeding.

1.10 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be affixed to each piece of equipment and resistant to ambient conditions.

B. All work shall include the following:

1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

D. Welding Standards:

1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

E. Pressure Piping Standards

1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.
2. Comply with ASME B31.9 Building Services Piping standard for the following services:
   a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
   b. Fluid pressure less than 350 psig.

3. Comply with ASME B31.3 Process Piping standard for the following services:
   a. Conveying fluid above 250°F (121°C).
   b. Toxic or flammable fluids.

F. Comply with minimum requirements in "Vents" chapter of local plumbing code including amendments from Authority Having Jurisdiction for termination height of vents above the roof due to localized frost and snow conditions.

1.11 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing without impacting adjacent equipment or piping. This work shall include furnishing and installing all access doors required for mechanical access. Joints and fittings shall not be located in inaccessible locations such wall, floor and roof penetrations.

E. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Coordinate all work with other disciplines before proceeding with installation.

F. Coordinate plumbing equipment and materials installation with other building components.

G. Piping dimensions, as identified on drawings and in specifications, refer to the interior free dimensions. Adjust work as necessary to account for larger outside dimensions to account for material wall thickness.

H. Verify all dimensions by field measurements.

I. Arrange for chases, slots, and openings in other building components to allow for plumbing installations.

J. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

K. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

L. Where mounting heights are not detailed or dimensioned, install plumbing services and overhead equipment to provide the maximum headroom possible.

M. Install plumbing equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

N. Coordinate the installation of plumbing materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

O. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

P. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

Q. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method and UL-2043.

R. Coordinate installation of floor drains and floor sinks with work of other trades. Finished floors shall slope to floor drains as shown on Architectural drawings. Floor sinks will typically be installed flush with surrounding floor. Review plans and design intent for floor sinks that may require elevated rims.

S. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

T. Pipes, pipe fittings, plumbing fittings and fixtures that come into contact with the wetted surface of a public water system or any plumbing in a facility providing water for human consumption shall be "Lead Free".

1.12 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all plumbing work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting the work. The contractor's scope of work shall include

1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications
2. Minor deviations from the plumbing plans required by architectural and structural coordination.

C. The Contractor shall study the operational requirements of each system, and shall arrange the work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems within the physical space available for use by this section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work." Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

D. Minor deviations in order to avoid conflict shall be permitted where the design intent is not altered.

E. Advise the Owner's Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

1.13 PRODUCT SUBSTITUTIONS

A. Coordinate all substitution requests with requirements of Division 01 work. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts are available locally and readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to the proposed substitution.

1.14 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Provide submittals for all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for review and approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:

1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
3. Paper submittals will only be acceptable if specifically required by Division 01.
4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.15 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.

1. The shop drawings shall serve to record the coordination of the installation and location of all piping, fixtures, HVAC equipment, ductwork, grilles, diffusers, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
2. The Drawings shall include all mechanical rooms and floor plans.
3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.
4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:

1. Two dimensional AutoCAD / Revit based documents:
   a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
   b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Plumbing drawings shall indicate locations of all fixtures and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Drawings shall incorporate all addenda items and change orders.
   f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

2. Three dimensional Revit / BIM based documents (if required for project):
   a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Model shall incorporate all addenda items and change orders.
   f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

1.16 REQUESTS FOR INFORMATION (RFIS)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).

1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
2. RFIs shall address single questions and related issues only.
3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect and Construction Manager.
6. RFI number, numbered sequentially and unique.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:
    a. Incomplete RFIs or inaccurately prepared RFIs.
    b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
    c. RFIs addressing multiple unrelated issues.
    d. Requests for approval of submittals.
    e. Requests for approval of substitutions.
    f. Requests for approval of Contractor's means and methods.
    g. Requests for information already indicated in the Contract Documents.
    h. Requests for adjustments in the Contract Time or the Contract Sum.
    i. Requests for interpretation of Engineer's actions on submittals.

2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.17 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked "Record Set" at the job site at all times, and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including locations control devices, and equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all "Record Set" notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.18 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. Operations and Maintenance (O&M) Manuals: Contractor shall submit to the Owner's Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section.

B. The Contractor shall be responsible for proper instruction of Owner's personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 22, to be no less than two (2) hours for each type of equipment.

C. Refer to Division 01 for additional requirements.

1.19 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with manufacturer's names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping

and equipment that is damaged or showing signs of rust shall be removed from site and replaced with new.

1.20 START-UP SERVICE

A. Prior to start-up, assure that systems are ready for start-up and commissioning, including checking the following: proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of controls, pumps, water heaters, and other major pieces of equipment. Certify in writing, compliance with this paragraph, stating names of personnel involved and the date work was performed.

C. Refer to other Division 01 and Division 22 sections for additional requirements.

1.21 TEMPORARY FACILITIES

A. Refer to Division 01 for the requirements of temporary water and sewer for construction and safety. Provide temporary water, and sewer, etc. services as necessary during the construction period and as required to maintain operation of existing systems.

1.22 UNIT PRICING SUBMITTALS

A. Prior to construction submit for review all materials and equipment and pricing in accordance with Division 01 requirements.

1.23 POSTED OPERATING INSTRUCTIONS

A. Print or engrave operating instructions and frame under glass or UV resistant plastic. Post instructions as directed by Owner's Representative. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.24 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work for the duration of the project.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each

of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.25 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner’s Representative.

1.26 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.27 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after the Certificate of Occupancy, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

C. All materials and equipment under this Division of the Specifications shall be new, of best grade and as listed in printed catalogs of the manufacturer.

D. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.

E. For secure facilities, schools and public safety buildings exposed equipment and access shall be Vandal Proofed. One type of vandal proof screw is to be used throughout this facility. Coordinate with General Contractor for type.

F. The following products to be included as part of this work but specified under Section 220500 Basic Plumbing Materials and Methods and Section 221000 Plumbing Piping, Valves and Specialties:

1. Piping.
2. Valves.
3. Hangers and supports.
4. Escutcheon plates, flashings, and sleeves.
5. Identification markers and signs.
6. Pressure and temperature gauges.
7. Access Panels.

G. Plumbing Fixtures: Refer to Section 224000.

H. Plumbing Equipment: Refer to Section 223000.

I. Products made of, or containing, lead, asbestos, mercury, or other known toxic or hazardous materials are not acceptable for installation under this Section. Any such products installed as part of the work of this Section shall be removed and replaced and all costs for removal and replacement shall be borne solely by the Contractor(s).

2.02 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:

1. UL: Provide products which are UL listed.
2. FM: Provide products which are FM approved.
3. ASCE 7-05: "American Society of Civil Engineers."
4. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
5. SMACNA: "Seismic Restraint Manual: Guidelines for Mechanical Systems."
6. NFPA: Pamphlet number 13 and 14 for fire protection systems.
7. Provide copper plated or plastic coated supports and attachments for copper piping systems. Field applied coatings or tape is unacceptable.
8. Manufacturer: Hilti Inc, B-Line/Tolco (Eaton), Anvil International, Erico, Empire, Kin-Line, Simpson, or Superstrut.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.

1. Adjustable Steel Clevis Hangers: MSS Type 1.
2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
3. U-Bolts: MSS Type 24.
4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
   a. Plate: Unguided type.
   b. Plate: Guided type.
   c. Plate: Hold-down clamp type.
5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Upper Attachment Side Beam Bracket: MSS Type 34
9. Upper Attachment Side Beam Angle Bracket: MSS Type 34, UL listed and FM Approved.
10. Single Pipe Roller with Malleable Sockets: MSS Type 41.
11. Adjustable Roller Hangers: MSS Type 43.
12. Pipe Roll Stands: MSS Type 44.
13. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp type by many manufacturers.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8 and or four-bolt riser clamps for heavy loads, MSS Type 42. Provide with 1" thick (minimum) neoprene pad on floor with 1/4" thick steel plate to distribute riser clamp weight to pad.

1. Pre-insulated two-bolt riser clamps up to 4" diameter. Manufacturer: Hydra-Zorb #Klo-Shure Titan Riser Clamp or equal.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.

1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated by the Structural Engineering design, provide factory-fabricated building attachments of one of the following types listed.

1. Concrete Inserts:
   a. MSS Type 18.
   b. Manufacturers: Hilti #KCS-MD (for metal deck) or HCI-WF (for wood forms), Simpson Strong Tie #Blue Banger Hanger, Powers Fasteners #Bang-It (for metal deck) or #Wood-Knocker (for wood forms), or equal.

2. Steel Brackets: One of the following for indicated loading:
   a. Light Duty: MSS Type 31.
   b. Medium Duty: MSS Type 32.
   c. Heavy Duty: MSS Type 33.

3. Horizontal Travelers: MSS Type 58.
4. Concrete Screw Anchors: For floor mounted attachments with maximum allowable pullout and shear force of 250 lbs. (1.1 kN) per anchor regardless of size.
   a. Manufacturers: Hilti #Kwik Hus EZ-I, Simpson Strong-Tie #Titen HD (or Rod Hanger version), Powers Fasteners #Wedge-Bolt+ (Screw Anchor), Powers Fasteners #Vertigo+ (Rod Hanger), Powers Fasteners #Snake+ (Internally Threaded Screw Anchor), or equal.

5. Torque-Controlled Expansion Anchor:
   a. Manufacturers: Hilti #Kwik Bolt TZ, Simpson Strong Tie #Strong-Bolt 2, Powers Fasteners #Power-Stud+ SD1 or Power-Stud+ SD2, or equal.

6. Screws and Bolts:
   a. Manufacturers: Bolt Depot, Fastenal, National Bolt & Nut, or equal.

7. Eye Bolts:
   a. Manufacturers: Lawson Products, Sierra Pacific, US Cargo Control, or equal.

8. Powder-Driven Concrete Anchors:
   a. Only for existing concrete structures with minimum 4000 psi concrete compressive strength.
   b. Minimum embedment of 1" (25 mm).
   c. Maximum allowable load of 50 lbs. (0.2 kN) per anchor.
   d. Manufacturer: Hilti #X or D Series, Powers Fasteners #CSI Series, or equal.

G. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
2. Insulation Protection Shields: MSS Type 40, 18" minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert. Alternately Polyisocyanurate Urethane with a minimum flexural strength of 60psi, fully encased in 360 PVC (1.524 mm thick) SNAPPITZ. Provide assembly of same thickness as adjoining insulation.
4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and join insulation at clevis hangers and strut-mounted clamps. Manufacturers: Klo-Shure Insulation Coupling or equal.

H. Miscellaneous Materials:

1. Metal Framing: Provide products complying with NEMA STD ML1.
2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards. Manufacturer: B-Line or equal.
5. Copper Pipe Brackets: Copper plated brackets. Insulate brackets attached to metal studs with felt. Manufacturer: HOLDRITE, Sioux Chief or equal.

2.03 SEISMIC RESTRAINT/VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 220548 Vibration Isolation for Plumbing Equipment or Section 220549 Seismic Restraint for Plumbing Piping and Equipment, as applicable.

2.04 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-penetration and membrane penetration of fire-resistance-rated assemblies shall be caulked, sealed and/or insulated as required to maintain the fire (F) rating and temperature rise (T) rating of the penetrated assembly. Install per manufacturer's installation instructions and conform with ASTM E814 or UL 1479 and comply with Chapter 7 of the Building Code. Refer to drawings for additional requirements.

B. Through-penetrations of rated floor assemblies by floor sinks, trench drains, and similar deep plumbing fixtures, shall be protected by a firestop system with an F rating and T rating of not

less than one hour but not less than the required rating of the floor penetrated. Manufacturer: 3M #System F-A-1131 or F-A-1160, Hilti #System F-A-1135 or F-A-1137, or equal systems as tested for specific installation.

C. Through-penetrations of rated floor assemblies by floor drains, tub drains or shower drains contained and located within the concealed space of a horizontal assemblies do not require compliance to a T rating.

D. Manufacturers: 3M, Hilti, Metacaulk, STI Firestop, ProSet or equal.

2.05 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20-gauge steel. 1" flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels is not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer or concealed valve. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner's Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, or Elmdor/Stoneman.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner's Representative.

2.06 PIPING

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties

2.07 VALVES

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties.

2.08 PLUMBING FIXTURES

A. Refer to Section 224000 Plumbing Fixtures.

2.09 ROOF FLASHING

A. Flashing: Unless indicated otherwise on the drawings the flashings for pipes through the roof shall be galvanized sheet metal, 24-gauge minimum, with seams and joints lapped and soldered watertight. Coordinate with Architectural documents for flashings and roofing.

B. Vent Pipes: Provide caulk type, vandal proof hood with Allen head vandal proof screws for all vent pipes through roof or preformed vinyl/galvanized steel assembly.

2.10 DRAINS

A. Manufacturers: J.R. Smith, Zurn, Wade, Sioux Chief, Josam, Watts, or equal.

B. Provide drains of type and size as indicated in plumbing schedule on Drawings, including features, as specified herein.

C. Floor drains and shower drains installed above food preparation, food handling and patient healthcare areas shall be provided with integral seepage holes that drain into the drain body/pan.

2.11 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 22 Sections. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.

1. Labels shall be printed to match the abbreviations or spelled out names used in the construction drawings. Custom printed labels are acceptable for specialty piping services and equipment.

B. Plastic Pipe Markers:

1. Pre-tensioned Pipe Labels: Precoiled, semi-rigid plastic formed to partially or fully cover the circumference of pipe, or insulated pipe, and to attach to pipe without fasteners or adhesive complying with ANSI A13.1. Minimum letter size shall be 1/2” high.
2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape. Minimum letter size shall be 1/2” high.
3. Insulation: Furnish 1” thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2” beyond each end of plastic pipe marker.
4. Arrows: Point each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
5. Pipe Label Color Schedule:
    a. Domestic Cold Water piping:
        1) Background Color: Green.
        2) Letter Color: White.
    b. Domestic Hot Water Supply and Domestic Hot Water Recirculation piping:
        1) Background Color: Green.

2) Letter Color: White.

c. Sanitary Sewer, Storm Drainage and Vent piping:
   1) Background Color: Green.
   2) Letter Color: White.

d. Natural Gas piping:
   1) Background Color: Yellow.
   2) Letter Color: Black.

C. Valve Tags:

1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4” high letters and sequenced valve numbers 1/2” high, and with 5/32” hole for fastener. Fill tag engraving with black enamel.
2. Plastic Laminate Valve Tags (indoors only): Provide 3/32” thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32” hole for fasteners.
3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves and manufactured specifically for that purpose.

D. Access Panel Markers: Provide 1/16” thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve.

E. Plastic Equipment Signs:

1. Provide 3” x 5” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2” high.
2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.

4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2”x11” bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

F. Underground-Type Plastic Line Markers: Provide 6” wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

G. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., Brimar or equal.

2.12 PIPE PORTALS

A. Where pipe portals are not provided by other sections of Specification, provide prefabricated insulated pipe portals as required for piping penetrating through the roof where shown on plans. Field built pipe portals are acceptable alternatives - provide detail of construction for review.

B. Standard pipe portals, unless otherwise noted, shall be constructed as follows:

1. Curb shall be constructed of heavy gauge galvanized steel with continuous welds on shell seams.
2. Insulation to be 1-1/2" thick, 3 lb. density rigid fiberglass.
3. Curb to have a raised 3" (minimum), 45° cant.
4. Curb to have 1-1/2" x 1-1/2" wood nailer (minimum).
5. Curb height to be 8" (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.
7. Cover or flashing to be constructed of galvanized steel or other suitable material to provide sturdy weather tight closure. Provide collars and rubber nipples with draw bands of sizes required by piping. Size curb, cover and nipples per manufacturer's recommendations.
8. Manufacturer: Roof Products Systems or Pate.

2.13 EQUIPMENT/PIPING RAILS

A. Where equipment/pipe rails are not provided by other sections of Specification, provide prefabricated reinforced equipment rails as required for support of equipment and piping. Field built curbs are acceptable alternatives - provide detail of construction for review.

B. Standard equipment rail, unless otherwise noted, shall be constructed as follows:

1. Construct of heavy gauge galvanized steel with continuous welds on shell seams.
2. Provide internal reinforcing supports welded as required to meet application requirements.
3. Equipment rails to have raised 3" (minimum), 45° cant.
4. Equipment rails to have 1 1/2" x 1 1/2" wood nailer (minimum) and counterflashing.
5. Equipment rail height to be 6" (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.

C. Equipment rails to be constructed to meet equipment size and weight requirements. Provide tapered rails to match roof pitch where required.

D. Manufacturer: Pate, Vent Products, Thy Curb or Roof Products Systems.

PART 3 - EXECUTION

3.01 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal or otherwise irregular work, unless so indicated on Drawings or approved by Owner's Representative.

C. Install all items specified in this section of the Specification under the full purview of local and state governing agencies.

3.02 PERFORMANCE OF WORK

A. Examine areas, physical conditions and phasing requirements under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings.

B. Work shall start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed. No foundry items to be installed until submittals have been approved.

C. Coordinate with other trades as necessary to properly interface components of the plumbing system.

D. Follow manufacturer's directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the drawings or covered in these Specifications.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.03 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles provided on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.04 INSTALLATION

A. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision, coordination or failure to make proper and timely provisions, the alterations shall be made to the satisfaction of the Owner's Representative and at the Contractor's cost.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defective materials.

3.05 SUPPORTS AND HANGERS

A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with all trades and testing agency representatives to coordinate work associated with placement of such work.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where gypcrete is indicated, install reinforcing bars through opening at top of inserts.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire, stranded wire, or perforated metal to support piping, and do not support piping from other piping.

E. Install a minimum of one hanger within 12" of each change of direction (only one required on either side of elbow), at the end of a pipe run or concentrated load, and within 36" of every piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

G. All fuel gas piping shall be installed in compliance with NFPA-54 (National Fuel Gas Code) and the local Building Code. All fuel gas piping shall be attached to the building with proper supporting systems.

1. Piping supports shall be designed and securely attached to the building to withstand special local conditions, such as wind and seismic forces, as defined in the Building Code and Chapter 5 of NFPA-54.
2. Fuel gas piping inside the building shall not be installed in or through elevator shafts, air ducts, laundry chutes, chimneys, vents or combustion air pathways.
3. Where piping is anchored to prevent undue strains on connected appliances and equipment this piping shall not be supported by other piping.
4. Support fuel gas piping independently of other piping exterior to the building.
5. Piping on roof tops shall be elevated a minimum of 6" above the roof surface and supported at maximum spacings as defined in Chapter 7 of NFPA-54 and per Code.

H. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

I. Horizontal Hanger Spacing in accordance with following minimum schedules (other spacings and rod sizes may be used in accordance with MSS SP-58 and the SMACNA Seismic Restraint Manual using a safety factor). Comply with more restrictive requirements of local codes where those exceed the following minimum criteria.

1. Cast Iron:

CAST IRON PIPE SIZE	HANGER/SUPPORT SPACING	ROD SIZE

	(MAXIMUM)	(MINIMUM)
Up to 4″	Each joint and 10 feet max	3/8″
Up to 8″	Each joint and 10 feet max	1/2″
Up to 12″	Each joint and 10 feet max	5/8″

2. Steel Pipe (Gas Filled to meet or exceed NFPA-54):

STEEL PIPE SIZE (GAS FILLED)	HANGER/SUPPORT SPACING (MAXIMUM)	ROD SIZE (MINIMUM)
1/2″	4 feet	3/8″
3/4″ to 2″	6 feet	3/8″
2-1/2″ to 4″	10 feet	1/2″
5″ to 8″	10 feet	5/8"

3. Copper Pipe (Water Filled):

COPPER PIPE SIZE	HANGER/SUPPORT SPACING (MAXIMUM)	ROD SIZE (MINIMUM)
1/2"	6 feet	3/8″
3/4″ to 2″	6 feet	3/8″
2-1/2″ to 4″	8 feet	3/8″
5″ to 8″	10 feet	1/2"

4. Provide a minimum of one hanger for each section of pipe. Where an excessive number of fittings are installed between hangers, provide additional reinforcing.

J. Vertical Support Spacing in accordance with following minimum schedules:

1. Cast Iron:

Pipe Size	Vertical Support Spacing (Maximum)
All sizes	Base and each floor, not to exceed 15 feet

2. Steel Pipe (Gas Filled):

Pipe Size	Vertical Support Spacing (Maximum)
1/2"	6 feet
3/4″ to 1″	8 feet
1-1/4″ and larger	Every floor level

3. Copper Pipe:

Pipe Size	Vertical Support Spacing (Maximum)
All sizes	Base and each floor, not to exceed 10 feet

K. Sloping, Air Venting, and Draining:

1. Slope all piping as specified and as indicated, true to line and grade, and free of traps and air pockets. Unless indicated otherwise, slope piping in the direction of flow as follows:

Service	Inclination	Slope
Soil and Waste	Down	1/4" per foot
Storm Water	Down	1/4" per foot
Sanitary Vent	Up (towards roof terminal)	1/4" per foot

2. Provide hose bibb valve, with threaded brass cap, at all low points in piping for maintenance draining.
3. Slope all compressed air branch piping down toward main risers at 1" per 100'.

L. Provisions for Movement:

1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units. Where hot water pipes are installed inside walls and ceilings do not firmly attach pipes to framing as necessary to avoid noise generation during expansion and contraction.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.
3. Insulated Piping: Comply with the following installation requirements:
   a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation.
   b. Shields: Where low compressive strength insulation or vapor barriers are indicated on cold water piping, install shields or inserts.
   c. Saddles: Where insulation without vapor barrier is indicated install protection saddles.

M. Installation of Anchors:

1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

N. Equipment Supports:

1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction. Coordinate size of concrete pads and placement of anchors bolts with structural design. Anchor bolts shall be placed to maintain 6", minimum, or greater distance from concrete pad edges.
2. Provide structural steel stands to support equipment that are not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

O. Adjusting:

1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

P. Sanitary Roof Vents:

1. Coordinate with Architect and Roofing Installer for required height of termination and support structure as required by local environmental requirements, such as local snow, ice and wind loads. Confirm that Architect and Roof Installer have provided deflectors or splitters on the roof to protect vents where required.

3.06 WALL, FLOOR, AND ROOF PENETRATIONS

A. All pipe penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Penetrations of fire-resistance-rated assemblies shall be protected by an approved firestop system installed and tested in accordance with ASTM E119, ASTM E814, UL 263 or UL 1479. The system shall have an F rating/T rating of not less than the required rating of the floor or wall penetrated. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below. Systems shall have an F rating of not less than 1 hour but not less than the required fire resistance rating of the assembly being penetrated. Systems protecting floor penetrations shall have a T rating of not less than I hour but not less than the required fire resistance rating of the floor being penetrated. Floor penetrations contained within the cavity of a wall at the location of the floor penetration do not require a T rating. No T rating shall be required for floor penetrations by piping that is not in direct contact with combustible material.

1. Uninsulated pipe penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1" (minimum) to 2" (maximum) larger than the outside diameter of each uninsulated pipe.
2. Insulated pipes penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1" (minimum) to 2" (maximum) larger than the outside diameter of each insulated pipe.
3. Uninsulated pipe penetrations through fire rated walls and floors, and through roof: penetration sizes shall be a 1/2" (minimum) to 1-1/2" (maximum) larger than the outside diameter of each uninsulated pipe to provide minimum 1/4" annular space between the outside of the pipe surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
4. Insulated pipe penetrations through fire rated walls and floors, and through roof: pipe penetration sizes shall be a 1/2" (minimum) to 1-1/2" (maximum) larger than the outside diameter of each insulated pipe to provide minimum 1/4" annular space between the outside of the insulation surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
5. Uninsulated pipe penetrations through foundation and basement walls: penetration sizes shall be larger than the outside diameter of each uninsulated pipe to allow adequate space for installation of mechanical link seals. Coordinate with specific manufacturer requirements.

3.07 PLUMBING FIXTURE THROUGH-PENETRATION AND MEMBRANE PROTECTION

A. Fire-resistance-rated assemblies shall be protected at membranes and/or through-penetrations where plumbing fixtures are installed in accordance with ASTM E119, ASTM E814, UL 263 or UL 1479.

B. Floor penetrations by floor drains, tub drains or shower drains contained and located within the concealed space of a horizontal assembly do not require a T rating as allowed by Chapter 7 of the Building Code.

C. Floor penetrations by floor sinks, trench drains and other fixtures that penetrate through the assembly must be enclosed within a rated enclosure with a comparable F/T rating of the assembly. Coordinate construction of fixture enclosures with Architectural design and General Contractor as required to comply with Chapter 7 of the Building Code.

D. Plumbing fixtures that penetrate into rated membranes, without penetrating through the membrane, shall be protected to maintain the fire-resistance rating of the assembly as required by Chapter 7 of the Building Code. Coordinate installation of fixtures with Architectural design and General Contractor. Manufacturer: 3M #Interam Endothermic Mat or equal.

3.08 WALL AND PIPE SIZING COORDINATION

A. Pipes routed horizontally or vertically in framed wall enclosures shall be limited to sizes that fit within the available free area without impacting the construction of the wall or intent of architectural floor plans. Maximum piping diameters shall be adjusted as necessary to accommodate insulation, fittings and pipe crossings inside the wall enclosure. Sizing is based on the following criteria:

1. 4” Stud Wall: Maximum 2” outside diameter of pipe and/or fittings.
2. 6” Stud Wall: Maximum 4” outside diameter of pipe and/or fittings.
3. 8” Stud Wall: Maximum 6” outside diameter of pipe and/or fittings.
4. 10” Stud Wall: Maximum 8” outside diameter of pipe and/or fittings.
5. 12” Stud Wall: Maximum 10” outside diameter of pipe and/or fittings.

3.09 ROOF CURBS, EQUIPMENT RAILS, PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed.

C. Verify roof insulation thickness and adjust cant to match.

3.10 PIPING INSTALLATION

A. The word “piping” shall mean all pipes, fittings, nipples, valves and all accessories connected thereto.

B. Run piping generally parallel to the axis of the building, arranged to conform to the building requirements and to suit the necessities of clearance for other mechanical ducts flues, conduits and work of other trades and close to ceiling or other construction as practical, free of unnecessary traps or bends.

C. Run horizontal sanitary drainage piping at uniform pitch of not less than 1/4" per foot (2%), unless otherwise indicated on the drawings. Pipe sizes 4” (100 mm) and larger may be sloped at 1/8” per foot (1%) as allowed by local plumbing code to serve required invert elevations. Pitch horizontal vent piping downward from stack to fixtures.

D. Each plumbing fixture shall be properly vented as required by local plumbing code. Sanitary sewer and vent pipe sizes shall be meet or exceed minimum requirements of the local plumbing code.

E. Ream or file each pipe to remove burrs. Inspect each length of pipe and each fitting for workmanship and clear passageway.

F. All piping shall be inspected for defects and flaws prior to installation. Remove any damaged piping from job site. Piping shall be thoroughly cleaned of dirt, debris or rust.

G. Cleanouts to be provided at each change in direction greater than 135° or 100' maximum intervals on underground piping.

H. Cleanout elevations shall be mounted flush with finished floor elevation.

I. Cleanouts to be same size as pipe except cleanout plugs larger than 4" shall not be required.

J. Cleanouts on concealed piping to be extended through and terminate flush with the finished wall or floor. Cover plates to be provided on all cleanout plugs in finished areas.

K. The bodies of cleanout ferrules to conform in thickness to that required for pipe and fittings of the same metal.

L. Provide cleanout on waste/vent riser serving each urinal. Locate cleanout above urinal where required by local code.

M. Attached piping on roof to manufactured polypropylene pipe supports, curbs or rails. Manufacturers: Caddy Pyramid, Roof Top Blox or equal.

3.11 VIBRATION CONTROL ISOLATORS

A. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

B. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit,

and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.12 PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Division 9: Painting. Painting schemes shall comply with ANSI A13.1. Paint all exposed materials such as piping, equipment, insulation, steel, etc. Exposed gas piping outside the building shall be painted.

B. All exposed work under Division 22 shall receive either a factory finish or a field prime coat finish, except:

1. Exposed copper piping.
2. Aluminum jacketed outdoor insulated piping.

3.13 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment. Identification is not required inside wall assemblies or under concrete slabs.

B. Piping System Identification:

1. Install pipe markers on each system indicated to receive identification and include arrows to show normal direction of flow.
2. Locate pipe markers as follows:
    a. Near each valve and control device.
    b. Near each branch, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
    c. Near locations where pipes pass through walls, floors, ceilings, or inaccessible enclosures.
    d. At access doors, manholes, and similar access points which permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.
    f. Spaced horizontally at maximum spacing of 50' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.
    g. For natural gas piping labels shall be spaced at intervals not exceeding five feet. Labels may be spaced horizontally at maximum spacing of 50' along each piping run where pipe is located in the same room or area as the appliance served, with minimum of one in each room or space. Vertically spaced at each story traversed.
3. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipe where flow is allowed in both directions.
4. Provide pipe identification on:
    a. Domestic cold water.
    b. Sanitary sewer and vent piping.
    c. Storm drainage piping.
    d. Natural gas piping.

C. Valve Tag Identification: Install tags on valves and control devices in piping systems, except at 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.

1. Provide valve tags for:
   a. Domestic cold water.
   b. Gas/fuel piping.

D. Where upstream gas pressure exceeds 2 psi, each gas pressure regulator shall have a metal tag attached stating, "Warning: upstream natural gas pressure. Do not remove."

3.14 CLEANING EQUIPMENT AND MATERIALS

A. In addition to the requirements of Section 220500, provide for the safety and good condition of all materials and equipment until final acceptance by the Owner's Representative. Protect all materials and equipment from damage. Provide adequate and proper storage facilities during the progress of the work. Special care to be taken to provide protection for bearings, open connections, pipe coils, pumps, compressors, and similar equipment.

B. All piping, finished surfaces, and equipment to have all grease, adhesive labels, and foreign materials removed.

C. All piping to be drained and flushed to remove grease and foreign matter. Pressure regulating assemblies, traps, flush valves, and similar items shall be thoroughly cleaned. Remove and thoroughly clean and reinstall all liquid strainer screens after the system has been in operation for ten days.

D. When connections are to be made to existing systems, the Contractor is to do all cleaning and purging of the existing systems required to restore them to the condition existing prior to the start of work.

3.15 TESTING

A. Provide all tests specified herein, in other Division 22 Sections, and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner's Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Owner's Representative to witness all field tests and conduct all field inspections. The Contractor to give the Owner's Representative ample notice of the dates and times scheduled for tests. Any deficiencies to be completely retested at no additional cost.

C. Inspection to continue during installation and testing. Perform a final inspection of the equipment prior to installation to determine conformity to the type, class, grade, size, capacity, and other characteristics specified herein or indicated. Correct or replace all rejected equipment prior to installation.

3.16 DISINFECTING - PLUMBING SYSTEMS

A. Disinfection of potable water distribution system shall be as prescribed by the local health authority or the following minimum requirement. After pressure tests have been made thoroughly flush the entire domestic water distribution system with water until all entrained dirt and mud have been removed and sterilize by chlorinating material. The chlorinating material shall be liquid chlorine. The chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the system or part thereof in an approved manner. Retain the treated water in the pipe for 24 hours, or, fill the system or part thereof with a water-chlorine solution containing at least 200 parts per million of chlorine and allow to stand for three (3) hours. Open and close all valves in the system being disinfected three times during the contact period. Then flush the system with clean potable water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period open and close all valves and faucets three times. From at least three divergent points in the system, take samples of water in properly sterilized containers for bacterial examination. Repeat the disinfecting until tests indicate that satisfactory bacteriological results have been obtained.

B. Taking of samples shall be witnessed by Owner's Representative. Samples are to be taken and tested by an independent analytical testing laboratory. Written reports shall be supplied to Owner's Representative for approval.

3.17 OPERATING TESTING AND CERTIFICATION - PLUMBING SYSTEMS

A. Upon completion and disinfection, and prior to acceptance of the installation, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory, functional, and operating efficiency. Such operating tests to include the following information in a report with conclusions as to the adequacy of the system.

1. Time, date, and duration of tests.
2. Water pressures at most remote location.
3. Operation of all valves and hydrants.
4. Operation of all floor drains by flooding with water.
5. Quality of domestic water.
6. Read all indicating instruments at half-hour intervals unless otherwise directed. Supply four copies of the test report to the Owner's Representative.

3.18 VIBRATION AND DYNAMIC BALANCING

A. All equipment submitted and installed by Division 22 shall not exceed maximum tolerances as specified by the equipment manufacturer and the Hydraulic Institute for pumps.

B. Where installed equipment noise or vibration is objectionable to the Owner's Representative, it shall be responsibility of the contractor to conduct testing to confirm that the equipment does not exceed the standard.

C. Correction shall be made to all equipment, which exceeds vibration tolerances.

END OF SECTION 220500

SECTION 220549 – SEISMIC RESTRAINT FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.02 SUMMARY

A. This Section includes the following:

1. Seismic restraint and support of piping, ductwork and mechanical equipment as required by code and as designed by project registered professional Structural Engineer.
2. Plumbing (mechanical) component supports and the means by which they are attached to the plumbing component shall be designed for the forces and displacements determined in ASCE 7 Chapter 13. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the plumbing component.

1.03 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. ASCE: American Society of Civil Engineers

C. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

D. IBC: International Building Code with Amendments

E. ICC-ES: ICC-Evaluation Service

F. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association

G. Building Seismic Design Category: The directions of application of seismic forces used in the design shall be those which will produce the most critical load effects. Seismic Design Categories are classified as A, B, C, D, E or F. Refer to Architectural and Structural Designs for project specific classification.

H. Mechanical Attachments: Means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

I. Mechanical Supports: Those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated

fasteners that transmit loads between nonstructural components and their attachments to the structure.

J. Mechanical Components: Elements, including, but not limited to, pumps, air handling units, boilers, chillers, pipes, ductwork, and exhaust fans.

K. Story Drift: The horizontal deflection at the top of the story relative to the bottom of the story.

1.04 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Structural Performance: Restraint devices and systems shall withstand the effects of locally defined gravity loads, seismic loads, dead loads, live loads, winds loads and stresses within limits and under conditions indicated according to the Building Code and ASCE 7. Coordinate all support structures and restraint systems with project registered professional Structural Engineer.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

D. Codes and Standards: Provide components conforming to the seismic load requirements of the latest addition of the local building code and the following:

1. International Building Code with State Amendments

2. ASCE 7-10 (Latest Edition) - Minimum Design Loads for Buildings and Other Structures
   a. Ductwork and piping requirements defined in Chapter 13 Seismic Design Requirements for nonstructural Components. Nonstructural components in Seismic Design Category A are exempt from seismic design requirements.

3. SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition)
   a. Seismic guidelines for ductwork and piping bracing as adopted by Authority Having Jurisdiction.

4. ASHRAE – Practical Guide to Seismic Restraint (Latest Edition)
5. ANSI/FM 1950: American National Standard for Seismic Sway Braces for Pipe, Tubing and Conduit (Latest Edition).
6. Factory Mutual (FM): Earthquakes Data Sheet 1-2 (Latest Edition).
7. Factory Mutual (FM): Earthquake Protection for Water-Based Fire Protection Systems Data Sheet 2-8 (Latest Edition).

8. Mason Industries/Mason West - Seismic Restraint Guidelines (Latest Edition)
   a. For all suspended piping.

1.06 APPLICABILITY

A. Refer to building design criteria provided on Architectural and/or Structural Engineering designs for seismic design criteria including Occupancy Category, Risk Category, Seismic Design Category, Component Importance Factor and Short Period Design Response Acceleration Parameter as required to determine the type of seismic restraints.

B. Seismic restraints are required for nonstructural plumbing systems, but may not be required for the following conditions related to nonstructural components per ASCE 7 Section 13.1.4:
   1. Plumbing components in Seismic Design Category A or B facilities.
   2. Plumbing components in Seismic Design Category C facility provided that the component Importance Factor, I_p, is equal to 1.0.
   3. Plumbing components in Seismic Design Categories D, E, or F facilities where **all** of the following apply:
      a. The component Importance Factor, I_p, is equal to 1.0;
      b. The component is positively attached to the structure;
      c. Flexible connections are provided between the component and associated ductwork, piping, and conduit; and any of the following applies:
         1) The component weighs 400 lbs. (1,780 N) or less and has a center of mass located four feet (1.22 m) or less above the adjacent floor level; or
         2) The component weighs 20 lbs. (89 N) or less; or
         3) The distributed piping system weights 5 lbs./ft. (73 N/m) or less.

C. Provide seismic bracing at the following locations per SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition):

   1. Piping:
      a. Transverse bracing shall be provided at 40 feet (12.2 m) maximum except where a lesser spacing is indicated in SMACNA tables.
      b. Longitudinal bracing shall be provided at 80 feet (24.4 m) maximum except where a lesser spacing is indicated in SMACNA tables. Anchor locations for thermal expansion may be used as longitudinal braces. Longitudinal braces must be capable of resisting the additional force induced by expansion and contraction.

D. Seismic restraints may be omitted where the following conditions apply and as allowed by the local Authority Having Jurisdiction (AHJ):

   1. Pipes suspended by hangers 12" (305 mm) or less in length from the top of the pipe to the bottom of the supporting structure for the hanger. Where pipes are supported by trapeze, the trapeze shall be supported by hangers having a length of 12” (305 mm) or less.
   2. Pipe bracing shall not be required where the following conditions apply:
      a. For Seismic Design Category C where the I_p value is greater than 1.0 and pipe sizes are 2” (50 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).
      b. For Seismic Design Category D, E, or F where the I_p is greater than 1.0 and pipe sizes are 1” (25 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).

c. For Seismic Design Category D, E, or F and where the I_p equals 1.0 and pipe sizes are 3" (80 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).

E. Seismically restrained piping systems shall not move more than 2" during a seismic event and shall not impact the building structure or other nonstructural components during a seismic event. The design force of restraint elements shall be doubled (2 x Fp) to allow for movement up to 2" per ASCE 7 Section 15.7.4.

1.07 PERFORMANCE REQUIREMENTS

A. Component Importance Factor and Risk Category:

1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components and piping conveying toxic or explosive material, including natural gas, propane and fuel oil.
3. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7 Section 13.1.3 regardless of Risk Category, or Hospitals and Correctional Treatment Centers. Components include, but are not limited to the following:
   a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
   b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the AHJ and is sufficient to pose a threat to the public if released.

B. Mechanical Seismic Coefficients for Mechanical Components: Refer to ASCE 7 Table 13.6-1 for a_p factor (component amplification factor) and R_p factor (component response modification factor) as required for each unique mechanical component.

1.08 SUBMITTALS

A. Product Data:

1. Include rated load, rated deflection, and overload capacity for each device or system.
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 or agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Submit seismic brace product details from the Mason West Seismic Restraint Guidelines detailing compliance with the specifications.
4. Where products from the Mason West Seismic Restraint Guidelines cannot be used, special details must be submitted for approval.

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

1. Seismic restraint calculations must be provided for all connections to the structure.
2. Calculations must be stamped by a registered professional Structural or Civil Engineer.
3. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. 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 was examined for excessive stress and that none exists.
5. Provide flexible joints, supports and piping joints as required to accommodate movement across seismic expansion joints and vertical building drift between floors.

1.09 ENGINEERED PIPING SYSTEMS

A. Where the piping system design indicated on the plans utilizes Mason Industries, Inc. - Mason West, Inc. seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors the following requirements apply:

1. Mason Industries, Inc. - Mason West, Inc. products must be installed as shown.
2. If product substitutions or design changes are made the contractor must provide certified design of the piping system and meet the following conditions:
   a. Certification must be provided by a registered professional Structural Engineer.
   b. Certification shall include a statement that all systems have been checked for loads and stresses and that no excessive loads or stresses exist.
   c. Forces on all anchors, guides, supports, and restraints must not exceed those shown in the original design unless the structure is checked for the larger loads at no cost to the owner.

B. Where the piping system design is not indicated on the drawings the design is delegated to the contractor with the following requirements for piping certification and analysis:

1. The supports, anchors, guides and seismic braces for systems with significant thermal motion including steam, condensate, high temperature hot water and heating hot water systems must be designed for combined gravity, seismic, pressure and thermal loads.
2. The results of the analysis shall include reactions at restraints and anchors, maximum pipe displacements and a code compliant report indicating maximum pipe stresses.
3. Where required, seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors manufactured by Mason Industries, Inc. and Mason West, Inc. shall be incorporated into the design of the systems.
4. The analysis and design must be performed by a Structural Engineer with 5 years of experience in this field.

1.10 MANUFACTURER AND CONTRACTOR RESPONSIBILITIES

A. All seismic restraints shall be designed by a registered professional Structural Engineer.

B. Seismic restraint layouts for piping shall be added to the contractor's shop drawings and shall include:

1. The number, size and location of seismic braces.
2. Maximum support loads and seismic loads at the seismic brace locations.
3. Reference to specific details or pages from the Mason West Seismic Restraint Guidelines.

C. Installations not addressed by the state pre-approval process must be designed, detailed and submitted along with the shop drawings.

D. Submit seismic restraint layout drawings and special details for approval of the project registered professional Structural Engineer per the requirements listed in the Mason West Seismic Restraint Guidelines.

E. Seismic restraint layout drawings shall bear the stamp and signature of the registered professional Structural Engineer who designed the layout of the braces.

1.11 LOADS ON STRUCTURE

A. The responsibility of determining allowable loads on the structure is the sole responsibility of the project registered professional Structural Engineer.

B. Maximum support loads and seismic brace loads on the structure must be less than the maximum allowable loads defined by the project registered professional Structural Engineer, as shown on the plans.

C. Where maximum loads are not listed on the plans or the maximum allowable loads cannot be met, any additional support steel required to reduce support and seismic bracing loads on the structure shall be designed by the project registered professional Structural Engineer.

D. Mechanical component supports and the means by which that are attached to the component shall be designed for the forces and displacements determined in ASCI 7-10 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

E. Mechanical supports are those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical attachments are the means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

1.12 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 INTENT

A. All seismic restraints described in this section shall be the product of a single manufacturer.

B. Mason Industries products are the basis of these specifications; products of other manufacturers may be submitted for review provided their systems strictly comply with the specifications.

2.02 SEISMIC SWAY BRACING

A. Seismic sway braces shall consist of galvanized steel aircraft cables, steel angles or steel struts.

B. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads. Brace end connections shall be steel assemblies that swivel to the final installation angle.

C. Cable brace assemblies shall have published strength and stiffness ratings based on testing per FM-1950 standards.

D. Angle or strut bracket assemblies shall be FM Approved except as noted below.

E. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps.

F. Cable brace bracket assemblies shall be Type SCB or SCBH. Solid brace bracket assemblies shall be Type SSB-FM, SSBS-FM or SHB-FM. All bracket assemblies shall have published strength and stiffness values based on testing per FM-1950.

G. Rod clamps shall be Type SRC or UCC.

H. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting small pipes and equipment.

1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

PART 3 - EXECUTION

A. Contractor’s Statement of Responsibility: Each contractor responsible for installing a Designated Seismic System or any seismic resisting component must submit a statement of responsibility prior to the commencement of work to include acknowledgment of awareness of the need for Special Inspections.

B. All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

C. Installation of seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

D. No connections between the piping and the building structure shall be made that degrades the seismic restraint system herein specified.

E. Any conflicts with other trades due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner's Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

END OF SECTION 220549

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:

1. Piping Services:
   a. Domestic cold water, unless otherwise noted on drawings.
   b. Roof and overflow roof drain piping and drain bodies. (See Drains below)
   c. Cooling coil condensate drainage.
   d. All valves, separators, strainers and fittings for systems listed above.

2. Roof Drains and Associated Piping: All roof and overflow drain bodies and associated piping are to be insulated except in Hot-dry and Mixed-Dry climate zones as defined by the National Renewable Energy Laboratory Building America zone map. See Pacific Northwest National Laboratory publication PNNL 17211, Guide to Determining Climate Regions by County.
3. Types of plumbing piping insulation specified in this Section include the following:
   a. Pipe insulation: Fiberglass.
   b. Pipe insulation: Flexible elastomeric closed cell foam.

4. Insulation jackets:
   a. Interior application
   b. Exterior application
   c. Removable covers

5. Types of plumbing equipment insulation specified in this Section include the following:
   a. Flexible elastomeric closed cell foam.
   b. Fiberglass blanket
   c. Fiberglass board
   d. Cellular glass.

6. Insulation accessories.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods.

1.04 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room, typically between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as "all service jacket" or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

1.05 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
   a. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
   b. C165 - Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
   c. C167 - Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.
   d. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission.
   e. Properties by Means of the Guarded-Hot-Plate Apparatus.
   f. C195 - Specification for Mineral Fiber Thermal Insulating Cement.
   g. C196 - Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
   h. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
   i. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
   j. C305 - Test for Thermal Conductivity of Pipe Insulation.
   k. C356 - Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
   l. C411 - Test for Hot-Surface Performance of High Temperature Thermal Insulation.
   m. C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

n. C449 - Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
o. C518 – Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p. C533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
q. C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
r. C547 - Specification for Mineral Fiber Preformed Pipe Insulation.
s. C552 - Specification for Cellular Glass Block and Pipe Thermal Insulation.
t. C553 - Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
u. C592 - Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
v. C612 - Specification for Mineral Fiber Block and Board Thermal Insulation.
w. C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
x. C921 - Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
y. C1104 – Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
z. C1071 - Standard Specification for Thermal and Acoustical Insulation.
aa. C1338 – Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
bb. D1667 – Standard Specification for Flexible Cellular Material-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
cc. E84 - Test Method for Surface Burning Characteristics of Building Materials.
dd. E119 - Test for Fire Resistance.
ee. G21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
ff. G22 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90 Energy Conservation in New Building Design.

3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255 Test Methods, Surface Burning Characteristics of Building Materials.

B. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

C. Products Containing Prohibited Chemicals:

1. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable:
   a. Pentabrominated diphenyl ether (CAS#32534-81-9)
   b. Octabrominated diphenyl ether (CAS#32536-52-0)
   c. Decabrominated diphenyl ether (CAS#1163-19-50

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed

index of 50 or less, as tested by ASTM E84 (NFPA 255) Method and UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Provide insulation such that when tested in accordance with the following test, the steel plate in contact with the insulation shows no greater corrosion than sterile cotton in contact with a steel plate for comparison.

1. Test Specimen: Two specimens shall be used, each measuring 1" by 4" by approximately 1/2" thick.
2. Apparatus: Provide a humidity test chamber in which two polished-steel test plates, 1" wide, 4" long and 0.020" thick, shall be placed. Plates shall be clear finish, cold-rolled strip steel, American quality, quarter hard, temper No. 3, weighing 0.85 lb/sq. ft.
3. Procedure: The steel test plates shall be rinsed with cp benzol until their surfaces are free from oil and grease and allowed to dry. One piece of cold-rolled steel shall be placed between the two insulation specimens and secured with tape or twine. The test specimen and uncovered plate shall be suspended vertically in an atmosphere having a relative humidity of 95% (plus or minus 3%), and a temperature of 120°F (plus or minus 3°F), for 96 hours, and then be examined for corrosion.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

1.06 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also furnish necessary test data certified by an independent testing laboratory. Submit samples.

B. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:

1. Pentabrominated diphenyl ether (CAS#32534-81-9)
2. Octabrominated diphenyl ether (CAS#32536-52-0)
3. Decabrominated diphenyl ether (CAS#1163-19-50

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.08 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Johns Manville, Owens-Corning, Knauf, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix, or approved equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.02 PIPE INSULATIONS (IDENTIFIED BY KEY CODE **PI**)

A. **PI-A**, Preformed Mineral Wool or Fiberglass:

1. Molded fibrous glass pipe insulation shall comply with the requirements of ASTM C 547 and meet ASTM C 585 for sizes required in the particular system. UL 723 or ASTM E84 compliant for Flame Spread Index of 25 or less and Smoke Developed Index of 50 or less. For all fluid distribution temperatures below 45· F the system shall be of a wicking type.
2. Non-Wicking.
3. Applications: Insulation of piping up to 18" in diameter and 3" thick insulation.
4. 'K' Value: 0.23 at 75°F.
5. Maximum Service Temperature: 850°F.
6. Flame spread index: ASTM E84 and UL 723, less than 25.
7. Smoke developed index: ASTM E84 and UL 723, less than 50.
8. Vapor Retarder Jacket: AP-T PLUS white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples or vapor barrier mastic as needed.
9. Manufacturers: Johns Manville #Micro-Lok HP, Owens Corning #SSL II, Knauf, einsulation, or equal.

B. **PI-B**, Flexible Closed-Cell Elastomeric or Neoprene:

1. Closed-cell, halogen free, elastomeric insulation.
2. Comply with ASTM-C177, ASTM E 84 and UL 181.
3. 'K' Value: 0.27 Btu· in./(hr· ft²· ºF) at 75°F.
4. Density: 3.0 to 6.0 lbs./cu.ft.
5. Maximum Service Temperature: 260°F.
6. Flame spread index: ASTM E84 and UL 723, less than 25.
7. Smoke developed index: ASTM E84 and UL 723, less than 50.
8. Seal all seams and joints with contact adhesive.
9. Manufacturers: Armacel #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel, or equal.

C. **PI-C**, Rigid Closed-Cell Cellular Glass:

1. Comply with ASTM C522.
2. 'K' Value: 0.34 Btu· in./(hr· ft²· ºF) at 140°F (60°C).
3. Density: 8.0 lbs./cu. ft.
4. Maximum Service Temperature: 900°F.
5. Flame spread index: ASTM E84 and UL 723, less than 25.
6. Smoke developed index: ASTM E84 and UL 723, less than 50.
7. Manufacturers: Pittsburgh-Corning #Foamglas with Pittwrap jacketing, or equal.

D. **PI-D,** Flexible High Temperature Aerogel:

1. High performance flexible insulation for specialty insulation applications with reduced available space for traditional insulation materials or higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. 'K' Value: 0.12 Btu· in./(hr· ft²· ºF) at 212°F (100°C). Thickness as required to meet energy code requirements.
4. Density: 10.7 lbs./cu. ft. (0.16 g/cc)
5. Maximum Service Temperature: 392°F (200°C).
6. Water Absorption, % of volume: <5% (maximum).
7. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
8. Manufacturer: Pacor #Pryogel 2250.

2.03 EQUIPMENT INSULATIONS (IDENTIFIED BY KEY CODE **EI**)

A. **EI-A**: Flexible Fiberglass Blanket:

1. Johns Manville Microlite Type 75 Flexible Blanket:
2. 'K' Value: ASTM C518, 0.27 Btu•in./(hr•ft²•ºF) at 75°F installed full thickness.
3. Maximum Service Temperature: 250°F.
4. Density: 0.75 lb/cu ft.
1. Flame spread index: ASTM E84 and UL 723, less than 25.
2. Smoke developed index: ASTM E84 and UL 723, less than 50.
5. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with fiberglass yarn and laminated to fire-resistant kraft, secured with UL listed pressure sensitive tape and/or outward clinched expanded staples and vapor barrier mastic as needed.

B. **EI-B,** Rigid Fiberglass Board:

1. Johns Manville Spin-Glass 814
2. 'K' Value: ASTM C518, 0.23 Btu•in./(hr•ft²•ºF) at 75°F.
3. Maximum Service Temperature: 250°F.
4. Density: 3.0 lb/cu ft.
5. Flame spread index: ASTM E84 and UL 723, less than 25.
6. Smoke developed index: ASTM E84 and UL 723, less than 50.
7. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with fiberglass yarn and laminated to fire-resistant kraft, secured with UL listed pressure sensitive tape and/or outward clinched expanded staples and vapor barrier mastic as needed.
8. Facing: 1” galvanized hexagonal wire mesh stitched on one face of insulation. (Optional.)

C. **EI-C,** Rigid Closed Cell Cellular Glass:

1. Pittsburgh-Corning Foamglas Meeting ASTM C552; Cellular Glass Thermal Insulation.
2. 'K' Value: 0.35 at 75°F.
3. Density: 8.0 lb/cu. ft.
4. Flame spread index: ASTM E84 and UL 723, less than 25.
5. Smoke developed index: ASTM E84 and UL 723, less than 50.
6. Maximum Service Temperature: 900°F.

D. **EI-D,** Flexible Closed-Cell Elastomeric or Polyethylene:

1. Armacel AP Armaflex, Rubatex K-Flex ECO, Aeroflex Aerocel, closed-cell, halogen free, elastomeric insulation. Comply with ASTM-C177, ASTM E 84 and UL 181.
2. 'K' Value: 0.27 at 75°F.
3. Density: 3.0 to 6.0 lbs./cu.ft.
4. Maximum Service Temperature: 260°F.
5. Flame spread index: ASTM E84 and UL 723, less than 25.
6. Smoke developed index: ASTM E84 and UL 723, less than 50.
7. Seal all seams and joints with contact adhesive.

E. **EI-E,** Rigid Hydrous Calcium Silicate

1. Johns Manville, IIG Thermo-12/Gold Meeting ASTM C533; Rigid Molded Block; Asbestos-Free Coded Throughout Material Thickness and Maintained Throughout Temperature Range:
2. 'K' Value: 0.40 at 300°F.
3. Maximum Service Temperature: 1,200°F.
4. Flame spread index: ASTM E84 and UL 723, less than 25.
5. Smoke developed index: ASTM E84 and UL 723, less than 50.
6. Compressive Strength (block): Minimum of 200 psi to produce 5% compression, based on 1-1/2" thickness.
7. Securement: Insulation shall be securely banded in place, tightly butted, joints staggered and secured with 16 gauge galvanized or stainless steel wire or ½" x .015" galvanized steel bands on 12" maximum centers for large areas.

F. **EI-F,** Flexible High Temperature Aerogel:

1. High performance flexible insulation for specialty insulation applications with reduced available space for traditional insulation materials or higher thermal performance is required.
2. Compliant with ASTM C177, ASTM C1728, ASTM C165, ASTM C1101/1101M, ASTMC1104/1104M, ASTM C1336, ASTM C1617, ASTM C1763, and ASTM E84.
3. 'K' Value: 0.12 Btu· in./(hr· ft²· ºF) at 212°F (100°C). Thickness as required to meet energy code requirements.
4. Density: 10.7 lbs./cu. ft. (0.16 g/cc)
5. Maximum Service Temperature: 392°F (200°C).
6. Water Absorption, % of volume: <5% (maximum).
7. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
8. Manufacturer: Pacor #Pryogel 2250.

G. **EI-G,** Fire Barrier Plenum Wrap for encapsulating non-rated (plastic) pipes and cables:

1. High-temperature, flexible, blanket insulation with FSK jacket that is NRTL (Nationally Recognized Test Lab) tested and certified. Apply one layer blanket to wrap combustible items in an air plenum area.
2. Density (minimum): 8 lb./cu.ft.
3. Thickness (minimum): 0.5" thick (13 mm).
4. Maximum operating temperature: 2300°F (1260°C).
5. Flame spread index: ASTM E84 and UL 723, less than 25.
6. Smoke developed index: ASTM E84 and UL 723, less than 50.
7. Manufacturer: 3M #Fire Barrier Duct Wrap 5A+, Unifrax #FyreWrap 0.5 Plenum Insulation, Morgan #FireMaster PlenumWrap or equal.

2.04 JACKETING MATERIALS

A. Field Applied Jackets (For Interior Applications):

1. All longitudinal seams shall be located on bottom of pipes.
2. PVC Plastic: One piece molded type fitting covers and jacketing material, gloss white. Connect with tacks and pressure sensitive color matching vinyl tape. Not allowed in ceiling return air plenums or other areas requiring flame/smoke spread rating less than 25/50. Manufacturers: Johns Manville Zeston 2000 or equal.
3. Canvas Jacket: UL listed fabric, 6 oz/sq. yd. plain weave cotton, treated with dilute fire retardant lagging adhesive.
4. Aluminum Jacket: 0.016" thick sheet, smooth or embossed] finish, with longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure aluminum jackets with 3/8" or 1/2" stainless steel bands on 12" centers.

B. Field Applied Jackets (For Exterior Applications):

1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
2. Aluminum Jacket: 0.016" (minimum) thick sheet, [smooth/embossed] finish, with longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner.
3. Stainless Steel Jacket: Type 304 stainless steel, 0.010" minimum (smooth/corrugated) finish.
4. Secure stainless steel or aluminum jackets with 3/8" or 1/2" stainless steel bands on 12" centers.
5. Manufacturers: Pabco, Childers, RPR, or approved equal.

C. Removable Covers:

1. Provide removable covers on pumps, backflow devices, valves greater than 2", flanges, strainers, etc., where periodic maintenance or removal of insulation may is required.
2. Use of pre-molded fittings with PVC covers is acceptable, unless noted otherwise.
   a. Cold systems: Provide PVC covers on elbows.
   b. Cold systems: Provide Armaflex elastomeric foam for flanges, valves, pumps and strainers.
   c. Hot systems: provide PVC covers on elbows and flanges.
   d. Hot Systems: provide removable blanket covers on valves, pumps, and strainers.
3. Removable- type silicon cloth fiberglass filled insulating blankets:
   a. 0-350°F service operating temperature.
   b. Jacket: silicon impregnated fiberglass cloth.

c. Liner: silicon impregnated fiberglass cloth.
d. Liner reinforcement: stainless steel mesh cloth.
e. Insulation: 1" type E glass matt, minimum.
f. Fastening: 2" nomex Velcro, 1" straps and stainless steel D-rings, or 12-gauge stainless steel hooks and stainless steel wire.
g. Thread: Kevlar/stainless steel thread.
h. Manufacturers: Fit Tight Covers, GLT products, or equal custom fabrication by Insulation Contractor.

PART 3 - EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.02 INSTALLATION

A. General:

1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Remove and replace any insulation that has become wet or damaged during the construction process.
3. Continue insulation and vapor barrier at penetrations and supports, except where prohibited by code.

B. Piping Insulation:

1. Locate insulation and cover seams in least visible locations unless otherwise specified.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Insulate all hot water and cold water pipes as defined in the following tables.
4. All insulation joints, lateral and longitudinal, shall be sealed to maintain integrity of vapor barrier to maximize thermal performance and minimize condensation potential.
5. Provide vapor retardant jackets on all insulated domestic cold water pipes, dual temperature pipes, and storm (rainwater) drain pipes, conveying fluids below 60°F with self-sealing laps. Insulate complete system. No staples shall be used.
6. For insulated pipes conveying fluids above 105°F, secure jackets with self-sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
7. Provide insert between support shield and piping on piping 1-1/2" diameter or larger. Fabricate of Johns Manville Thermo-12, or other heavy density insulating material suitable for temperature. Insulation inserts shall not be less than the following lengths:
   a. 1-1/2" to 2-1/2" pipe size 10" long
   b. 3" to 6" pipe size 12" long
   c. 8" to 10" pipe size 16" long

d. 12" and over 22" long

8. Use of metal saddles is acceptable as specified in Section 220500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
9. Use of pipe hangers designed as an insulation coupling is acceptable in lieu of saddles and other devices. Manufacturer: Klo-Shure coupling or equal.
10. For pipe exposed in mechanical equipment rooms or in finished spaces below 7 feet above finished floor, finish PVC jacket and fitting covers. Manufacturers: Johns Manville #Zeston 2000 PVC or equal.
    a. Where pumps, valves, strainers, etc., with insulation require periodic opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
    b. Cold systems: Provide Armaflex elastomeric foam for pumps and strainers.
11. For insulated pipes exposed inside the building in corridors, offices, conference room, lobbies and similar occupied spaces cover the insulation with PVC jacket and fitting covers. Manufacturers: Johns Manville #Zeston 2000 PVC or equal.
12. Insulate all sanitary sewer pipes and drainage fixture bodies where piping is located above food preparation, food handling and patient healthcare areas conveying fluids below 60°F.
13. For exterior applications:
    a. Provide weather protection jacket. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. Jacket seams shall be located on bottom side of horizontal piping. All lateral joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).
    b. Apply weather-resistant protective finish such as WB Armaflex to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping. All lateral and longitudinal joints to be sealed with low VOC UV inhibitive adhesive. Manufacturers: Armaflex #520 BLV or equal.
14. For underground installations, install per manufacturer's written instructions and recommendations.
15. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.

C. ENCAPSULATING NON-RATED PIPES AND CABLES

D. Where combustible non-fire rated pipes (plastic) and cables are installed in an air plenum space provide one layer of EI-G fire barrier plenum wrap to fully encapsulate the item to comply with ASTM E84 or UL-723.

3.03 PIPING INSULATION SCHEDULE

A. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED.

1. All insulation thicknesses shall meet or exceed State and Local Energy Code requirements as noted below. Provide additional insulation as required in the following sections. Increase all thicknessed by 1/2” where piping is exposed to exterior ambient air. Minimum thermal resistance in range of 4.2 to 4.6 per inch of thickness. Insulation

thicknesses are based on fiberglass insulation and may be adjusted for equivalent insulation values for materials with superior "K" factors.

INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
PI-A	Preformed Mineral Wool or Fiberglass
PI-B	Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene
PI-C	Rigid Closed-Cell Cellular Glass
PI-D	Flexible High Temperature Aerogel:
EI-A	Flexible Fiberglass Blanket
EI-B	Rigid Fiberglass Board
EI-C	Rigid Closed-Cell Cellular Glass
EI-D	Flexible Closed-Cell Elastomeric or Polyethylene
EI-E	Rigid Hydrous Calcium Silicate
EI-F	Flexible High Temperature Aerogel

TABLE 1:
PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED

SERVICE	PIPE SIZE (inches)	THICKNESS (inches)	MATERIAL OPTIONS
Domestic cold water.	All Sizes	1	**PI-A or PI-B.** See subsections below for required locations.
Storm (rainwater) primary and overflow (secondary) drainage piping.	All sizes	1	**PI-A or PI-B.** See subsections below for required locations.
Storm (rainwater) primary and overflow (overflow) drain bodies.	All sizes	1	**PI-A or PI-B.** See subsections below for required locations.
Heat-Traced liquid containing piping exposed to freezing.	All Sizes	1-1/2	**PI-A or B**. Provide aluminum jacket and label "heat traced" along with service designator label
Plumbing vents within 10 feet of the exterior in freezing climates.	All Sizes	1	**PI-A or B**
Cooling coil condensate drain piping and traps located outdoors.	N/A	N/A	**Not required.**
Where uninsulated plastic tubing/piping is installed in a return air plenum that does not meet ASTM E-84 provide insulation wrap.	All Sizes	1/2	**PI-A or B**

B. TABLE 2: CODE MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.

1. Oregon

TABLE 2 INSULATION BASED ON OREGON OEESC ENERGY CODE MINIMUM PIPE INSULATION THICKNESSES OR GREATER							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 and 1-1/4	1-1/2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water)							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
Service water-heating systems (recirculating sections, all piping in electric trace tape systems, and the first 8 feet of piping from the storage tank for non-recirculating systems)							
Above 90	0.24-0.27	100	1.0	1.0	1.0	1.0	1.0
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

3.04 EQUIPMENT INSULATION SCHEDULE

A. TABLE 3: EQUIPMENT INSULATION SCHEDULE FOR EQUIPMENT NOT FURNISHED WITH FACTORY INSULATION

TABLE 3 EQUIPMENT INSULATION SCHEDULE FOR EQUIPMENT NOT FURNISHED WITH FACTORY INSULATION			
EQUIPMENT	THICKNESS (inches)	REMARKS	MATERIAL OPTIONS
Water softeners/brine tanks	1	Provide vinyl or aluminum jacket	**EI-A, B, C, D**
Hot water storage tanks	2	Provide vinyl or aluminum jacket	**EI-B, C**
Hot water storage tanks	1	Provide vinyl or aluminum jacket	**EI-F**
Cold water storage tanks	1-1/2	Provide vinyl or aluminum jacket	**EI-D**

3.05 DOMESTIC COLD WATER INSULATION (BUILDING INTERIOR)

A. For domestic cold water piping which is located within the interior of the building envelope, on either side of building insulation barrier, and located in a humid climate as defined by or local indoor humid environments, shall be insulated for the first 100 feet of piping, from the point of building entry, with 1" (minimum) fiberglass insulation or elastomeric foam. In addition, exposed cold water piping in restaurants and kitchen and other high humidity spaces shall also

be insulated to prevent condensation. Insulate all piping passing over any electrical equipment or critical Owner provided equipment. Piping strategically installed inside insulated walls, roof or ceiling construction may not require additional insulation as deemed appropriate by the Owner's Representative.

3.06 ROOF PRIMARY AND OVERFLOW (SECONDARY) DRAINAGE PIPE INSULATION (BUILDING INTERIOR)

A. Inside conditioned buildings where storm (rainwater) primary and overflow (secondary) bodies and piping are exposed to building air, insulate all exposed storm (rainwater) drainage (primary and overflow) piping, horizontal and vertical.

B. For buildings located in freezing climates, with extreme winter temperatures below freezing:

1. Insulate all concealed storm (rainwater) primary and overflow (secondary) drain bodies and piping (horizontal and vertical) above grade.

C. For buildings located in non-freezing climates, with extreme winter temperatures above freezing:

1. Insulate all concealed storm (rainwater) primary and overflow (secondary) drain bodies.
2. And, insulate all primary and overflow storm (rainwater) piping, horizontal and vertical, located within 20 feet of the drain bodies.
3. And, insulate additional horizontal primary and overflow storm (rainwater) drainage piping, above grade and any floor, which extends beyond the 20 foot as necessary to minimize condensation potential.

D. Roof drainage piping strategically installed inside insulated walls, roof or ceiling construction may not require additional insulation as deemed appropriate by the Owner's Representative.

END OF SECTION 220700

SECTION 221000 - PLUMBING PIPING, VALVES AND SPECIALTIES

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to the following:

1. Pipe and Fittings
    a. Sanitary waste and vent
    b. Rainwater drain and overflow
    c. Potable Cold water
    d. Fuel gas

2. Valves
    a. Water valves
    b. Fuel gas valves
    c. Solenoid valves

3. Piping specialties
4. Pipe escutcheons
5. Unions
6. Sleeve seals
7. Gas connectors

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods, including:

1. Hangers and supports.
2. Roof flashings.
3. Cleanouts.
4. Access panels.
5. Identification.

B. Section 224000: Plumbing Fixtures.

C. Division 26: Electrical.

1.04 REFERENCE STANDARDS

A. Comply with requirements of latest standard or as required by local AHJ.

B. American National Standards Institute (ANSI)/American Welding Society (AWS):

1. ANSI/AWS A5.8: Specification for Filler Metals for Brazing.
2. ANSI/AWS A5.31: Specification for Fluxes for Brazing and Braze Welding.
3. ANSI/AWS B2.2: Standard for Brazing Procedure and Performance Qualification.
4. ANSI/AWS C3.4: Specification for Torch Brazing.
5. ANSI LC4: Press-Connect Metallic Fittings for use in Fuel Gas Distribution System.
6. ANSI/NSF 14: Plastics Piping System Components and Related Materials.

C. American National Standards Institute (ANSI)/American Water Works Association (AWWA):

1. ANSI/AWWA A21.10: Ductile-Iron and Gray-Iron Fittings.

D. American Society of Mechanical Engineers (ASME):

1. ASME Boiler and Pressure Vessel Code.
2. ASME B1.20.1: Pipe Threads, General Purpose.
3. ASME B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
4. ASME B16.22: Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
5. ASME B16.23: Cast Copper Alloy, Solder-Joint, DWV Drainage Fittings.
6. ASME B16.24: Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150 and 300.
7. ASME B16.29: Wrought Copper, and Wrought Copper Alloy Solder-Joint Drainage Fittings, DWV.
8. ASME B16.26: Cast Copper Alloy Fittings for Flare Copper Tubes.
9. ASME B16.50: Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.
10. ASME B16.51: Cast and Wrought Copper and Copper Alloy Press-Connect Pressure Fittings.
11. ASME B31.8: Gas Transmission and Distribution Piping Systems.
12. ASME A112.6.4: Roof, Deck, and Balcony Drains.
13. ASME A112.6.9: Siphonic Roof Drains.

E. American Society for Testing and Materials (ASTM):

1. Mechanical Couplings: ASTM A 536, ductile iron, or ASTM A 47, malleable iron coupling housing fabricated to manufacturer's specifications.
2. ASTM B584: Cast Copper Alloy for Grooved-End Fittings.
3. ASTM B75: Seamless Copper Tube for Grooved-End Fittings.
4. ASTM B32: Standard Specification for Solder Metal.
5. ASTM B88: Standard Specification for Seamless Copper Water Tube.
6. Hard Copper Tube: (Drawn Temper):
    a. ASTM B75: UNS Number C12200, drawn temper, seamless copper tube, wall thickness as specified.
    b. ASTM B88: Types K, L, and M, drawn temper, seamless copper tube.
    c. ASTM B306: Type DWV, drawn temper, seamless copper tube.
    d. ASTM B819: Type K and L, drawn temper, seamless copper tube.
    e. ASTM B837: Type GAS, drawn temper, seamless copper tube.

7. Soft Copper Tube:(Annealed Temper):
   a. ASTM B75: UNS Number C12200, annealed temper, seamless copper tube, wall thickness as specified.
   b. ASTM B88: Types K and L, annealed temper, seamless copper tube.
   c. ASTM B280: Type ACR, annealed temper, seamless copper tube.
   d. ASTM B837: Type GAS, annealed temper, seamless copper tube.

8. ASTM B306: Copper Drainage Tube (DWV).
9. ASTM B584: Copper Alloy Sand Castings for General Applications.
10. ASTM B813: Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube.
11. ASTM B819: Seamless Copper Tube for Medical Gas Systems.
12. ASTM B828: Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
13. ASTM B837: Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.
14. ASTM D3311: Standard Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns.
15. ASTM D2513: Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
16. ASTM A47: Ferritic Malleable Iron Castings.
17. ASTM A536: Ductile Iron Castings.
18. ASTM D1784: Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
19. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
20. ASTM F2014: Standard Specification for Non-Reinforced Extruded Tee Connections for Piping Applications.
21. ASTM F2389: Standard Specification for Pressure-Rated Polypropylene (PP) Piping Systems.
22. ASTM F2618: Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Fittings for Chemical Waste Drainage Systems.
23. ASTM F441: Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
24. ASTM F493: Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

F. American Society of Plumbing Engineers (ASPE)/American National Standards Institute (ANSI):

G. Cast Iron Soil Pipe Institute (CISPI):

1. CISPI 301: Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications (ASTM B 888)
2. CISPI 310: Specification for Coupling for Use in Connection with Hubless Cast iron Soil Pipe and Fittings for Sanitary and Storm Drain Waste, and Vent Piping

H. Factory Mutual (FM):

1. FM-1680: Standard to evaluate intended application for long-term connection to hubless cast iron soil pipe aboveground and underground. Class I for Industrial/Commercial and Residential to 15 psi working pressure.

I. National Fire Prevention Association (NFPA):

1. NFPA-54/ANSI-Z223.1: National Fuel Gas Code.
2. NFPA-58: Liquefied Petroleum Gas Code.

J. Joining Materials

1. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
   a. ASME B16.21, nonmetallic, flat, asbestos-free, full-face type for Class 150 and 300 cast copper alloy flanges. 1/8-inch maximum thickness, except where thickness or specific material is indicated.

2. Mechanical Coupling Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
   a. Gasket design shall be such that the entire coupling housing is isolated from the system contents to prevent galvanic action and inhibit galvanic corrosion.

3. Proprietary filler metals having compositions not conforming to the exact ANSI/AWS A5.8 classifications for BCuP and BAg Series filler metals shall be permitted when used according to the manufacturer's written instructions.
4. Soldering and Brazing Fluxes: Soldering and brazing fluxes shall not exceed 0.20 percent Lead (Pb) content for any work in potable water systems.
   a. Soldering Fluxes: ASTM B813, liquid or paste type.
   b. Brazing Fluxes: ANSI/AWS A5.31, Type FB3-A or FB3-C.
   c. The use of brazing flux is not necessary if the components being joined are wrought copper tube, wrought copper fittings and the filler metal being used is of the BCuP series.
   d. Solder flux should not exceed any VOC regulatory limitations at the time of installation. Flux is currently considered a low emitting material with no VOC regulations, but must be confirmed with prior to installation.

5. ASTM B32 Solder Filler Metal:
   a. Alloy Sn95 or Alloy Sn94: Tin (Sn) approximately 95%, and Silver (Ag) approximately 5%, having 0.10% maximum Lead (Pb) content.
   b. Alloy Sb5: Tin (Sn) 95%, and Antimony (Sb) 5%, having 0.20% maximum Lead (Pb) content.
   c. Alloy E: Tin (Sn) approximately 95%, and Copper (Cu) approximately 5%, having 0.10% maximum Lead (Pb) content.

6. ANSI/AWS A5.8 Brazing Filler Metals:
   a. BCuP Series: Copper-Phosphorus alloys. The following brazing filler metals shall be used. Brazing filler metals shall conform to the requirements of the individual piping systems.
      1) BCuP - 2: Copper (Cu) and Phosphorus (P) 7.0 - 7.5%.
      2) BCuP - 3: Copper (Cu), Phosphorus (P) 5.8 - 6.2%, and Silver (Ag) 4.8 - 5.2%.
      3) BCuP - 4: Copper (Cu), Phosphorus (P) 7.0 - 7.5%, and Silver (Ag) 5.8 - 6.2%.
      4) BCuP - 5: Copper (Cu), Phosphorus (P) 4.8 - 5.2%, and Silver (Ag) 14.5 - 15.5%.

1.05 QUALITY ASSURANCE

A. Manufacturers Qualifications:

1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

B. Codes and Standards:

1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.
2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes.
3. Perform all tests required by governing authorities and as required under all Division 22 Sections. Provide written reports on all tests.
4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.
5. All plumbing work shall comply with the Americans with Disabilities Act (ADA).

C. All materials (such as piping, insulation, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall be noncombustible or shall have a flame-spread index of not more than 25 and smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified elsewhere in the construction drawings. Contractor shall review all mechanical and architectural plans and be fully aware of all building design criteria prior to installation of any work. Any work installed that does not comply with applicable life/safety requirements of all codes and standards shall be replaced and/or repaired at no additional cost to the Owner.

D. Welding Standards:

1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

E. Pressure Piping Standards

1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.

2. Comply with ASME B31.9 Building Services Piping standard for the following services:
   a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
   b. Fluid pressure less than 350 psig.

3. Comply with ASME B31.3 Process Piping standard for the following services:
   a. Conveying fluid above 250°F (121°C).
   b. Toxic or flammable fluids.

1.06 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. CSA: Formerly known as the Canadian Standards Association (CSA). CSA Group is a member of ISO. CSA is accredited by US OSHA as a Nationally Recognized Testing Laboratory (NRTL).

C. Gas Appliance Pressure Regulator: A pressure regulator for controlling pressure to the appliance manifold.

D. Line Pressure Regulator: A pressure regulator placed in a gas line between the service regulator and the appliance regulator.

E. Lead Free: Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining "weighted average".

F. NRTL: Nationally Recognized Testing Laboratory, including UL, CSA and/or ETL.

1.07 WORKING PRESSURES

A. All fittings, valves, pipe, specialties equipment shall be rated for the working pressure subjected in the installed locations.

B. Drawings indicate working pressure in each system. The rating of the equipment and material shall not be less than that of the system pressures.

C. Low pressure gas service generally includes pressures ranging from 7" to 11" (less than 0.5 psi) to serve gas appliances downstream of pressure regulators.

D. Medium pressure gas service generally includes pressures ranging from 0.5 psi to 5 psi to distribute gas downstream of utility provided service regulators.

E. High pressure gas service generally includes pressures greater than 5 psi including utility distribution pressures and additional installation restrictions where installed within buildings.

1.08 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for all piping, valves and specialties indicating dimensions, valve CV, tolerances etc.

B. Shop Drawings: Submit shop drawings indicating underground piping installation showing all fittings with inverts. Indicate all footings and grade beams.

C. Maintenance Data: Submit maintenance instructions on accordance with requirements of Division 01.

D. Delegated-Design Submittal for each vibration isolation and seismic-restraint device.

1. Seismic restraint calculations must be provided for all connections to the structure.
2. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. 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 was examined for excessive stress and that none exists.
4. Provide flexible joints, supports and piping joints as required to accommodate movement across seismic expansion joints and vertical building drift between floors.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

C. Provide the additional extended warranty requirements that apply to all plastic piping systems with all types of joints and fittings.

1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
2. Contractor and Manufacturer warrant that, for a period of twenty-five (25) years from the date of Substantial Completion, the tubing will conform to the requirements of the Contract Documents and will be free from defects.
3. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
4. In addition to the Contractor's and Manufacturer's obligations set forth above and elsewhere, if, within two (2) years after the date of the Substantial Completion, any part of the system is found to be defective or not in accordance with the requirements of the Contract Documents, the Contractor or Manufacturer, or both, shall correct it at their own expense promptly after receipt of written notice from the Owner to do so.
5. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

1. Upon request, the Owner's Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

B. Type M copper piping is not acceptable for any pressure water piping unless specifically noted otherwise.

C. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturer's names used herein, unless specifically noted that substitutes are not allowed.

2.02 STANDARD PIPE AND FITTING

A. Domestic Cold Water Pipe & Fittings (Aboveground):

1. Seamless copper tube, pipe sizes 1/2" to 8":
   a. ASTM B88 or B75, Type K or L, annealed (soft) temper.
   b. ASTM B88 or B75, Type K or L, hard temper.
   c. Manufacturers: Mueller Streamline, Cerro Flow Products, or equal.

2. Fittings-Soldered:
   a. ASME B16.22 wrought copper alloy.
   b. ASME B16.18 cast copper alloy.
   c. Manufacturers: Nibco, Mueller, or equal.

3. Fittings-Brazed:
   a. ASME B16.50 wrought or copper alloy.
   a. Manufacturers: Nibco, Mueller, or equal.

4. Joints-Soldered:
   a. ASTM B32 filler metals. Manufacturers: Canfield #Silverflo or #Watersafe, Lucas Milhaupt #Silvabrite 100, or equal.
   b. Water soluble, lead free flux. Manufacturers: Oatey #H-20-95, JW Harris #Bridgit, La-CO #FLUX-RITE 90, Rectorseal #Nokorode, LucasMilhaupt #Silvabrite 100 or #95/5, or equal.

5. Joints-Brazed:
   a. ANSI/AWS A5.8 filler metals. Manufacturers: Canfield #Sil-Can 5 or #Sil-Can 15, LucasMilhaupt #Sil-Fos, or equal.

b. Water soluble, lead free flux. Manufacturers: JW Harris #Safety-Silv, LucasMilhaupt #Handy Flux, or equal.

B. Sanitary Sewer, Vent, Rainwater Pipe & Fittings up to 15":

1. Pipe and Fittings: Cast iron, bituminous coated or epoxy coated with "No-Hub" fittings complying with ASTM A74, ASTM A888, CISPI 301. Manufactured by AB&I, Charlotte, Tyler, New Age or equal.
2. Couplings Underground: Heavy Duty Type 301 or 304 stainless steel couplings conforming to ASTM C1540 with heavy-duty shield and neoprene sealing sleeve conforming to ASTM C564, CISPI 301 and FM-1680. Minimum four bands up to 4" diameter and six bands for 5" and larger diameters. Manufacturers: Anaco Husky #SD-4000, Clamp-All (Norma Group) #Hi-Torq 125, Mission #HeavyWeight, Ideal Tridon #HD, or equal.
3. Couplings Aboveground: Type 301 or 304 stainless steel couplings conforming to ASTM C1540 with heavy-duty shield and neoprene sealing sleeve conforming to ASTM C-564, CISPI 310 and FM-1680. Manufacturers: Anaco Husky #HD-2000, Clamp-All (Norma Group) #Hi-Torq 80, Mission #HeavyWeight, Ideal Tridon #MD, or equal.

C. Fuel Gas Pipe & Fitting (Aboveground Natural Gas/Propane/LP Gas/LNG):

1. Pipe: ASTM A53, Schedule 40 black steel.
2. Fittings: 150 lb. rating, ASME B16.3, malleable iron threaded; ASME B16.5, flanged; ASME B16.9, steel.
3. Joints 2" and smaller: Threaded in accessible areas. Welded in concealed areas such as shafts and plenums.
   a. Optional: Steel compression fittings shall conform to the material and sizing requirements of ASME B16.3 or ASTM A420. Fittings shall have an HNBR O-ring seal, 420 stainless steel grip ring, and 304 stainless steel separator ring. Manufacturers: Viega #MegaPress G or approved equal.

4. Joints 2-1/2" and larger: ASME B16.25 bevelweld, ASME B16.5 flanges, or ASME B16.11 socket weld. Welded in concealed areas such as shafts and plenums.
5. Welded Fittings: Comply with ASTM A234/A234M, ASME B16.9, ASME B16.25, and ASME B16.11.

   a. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
   b. Shop fabricated Bonney Forge "Weldolet" or "Thredolet" type fittings may be used in lieu of tee fittings, but field (site) welding will not be permitted.

6. Steel:
   a. Pipe: ASTM A53, Schedule 40 black steel or galvanized steel pipe.
   b. Fittings: 150 lb. or 300 lb. rating, ASME B16.3, malleable iron threaded; ASME B16.5, carbon steel flanges; ASME B16.9, butt-welding fittings.
   c. Joints: Threaded or flanged in accessible areas. Welded in concealed areas such as shafts and plenums.

2.03 VALVES: GENERAL

A. General: Valve ratings shall exceed respective system operating pressures by 50% (minimum). All valves shall be line size unless otherwise noted. Use ball valves, butterfly valves or angle stop valves for manual shut-off. Gate valves may be used in backflow preventer assemblies.

B. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing manufacturer's figure number, size, location, and valve features for each required valve.

C. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

D. Acceptable manufacturers (manufacturer and model number listed for individual valves indicates minimum acceptable by all manufacturers):

1. Manual Ball or Butterfly Shutoff: Apollo, Hammond, Nibco (commercial grade, US manufacturer only), Milwaukee, Victaulic, Watts or equal.
2. Check: Apollo, Hammond, Nibco (commercial grade, US manufacturer only), Milwaukee, Victaulic, Watts or equal..

E. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on the valve body.

F. Valve Features:

1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
2. Lead-Free Construction: NSF Standard 61 compliant. California AB1953 and Vermont S512 compliant for valves conveying water for human consumption.
3. Drain: Comply with MSS SP-45 and provide threaded pipe plugs.
4. Flanged: Valve flanges complying with ASME B16.1 (cast iron), ASME B16.5 (steel), or ASME B16.24 (bronze).
5. Threaded: Valve ends complying with ANSI B2.1.
6. Solder-Joint: Valve ends complying with ASME B16.18.
7. Flangeless: Valve bodies manufactured to fit between flanges complying with ASME B16.1 (cast iron), ASME B16.5 (steel), or ASME B16.24 (bronze).

2.04 DOMESTIC PLUMBING SERVICE VALVES

A. Ball Valves:

1. 2" and Smaller: 600 psi, 2-piece, bronze body, soldered ends for copper pipe and threaded ends for iron pipe, chrome plated brass ball, Teflon seat, brass stem, steel handle, full port, low lead compliant. Manufacturers: Milwaukee #UPBA-400 Series (Threaded), Milwaukee #UPBA-450 Series (Sweat), Apollo Lead Free #77CLF Series or equal.

2.05 FUEL GAS (NATURAL/LP/LNG) AND OIL SERVICE VALVES

A. General: All valves to be UL listed for the required fluid service.

B. Ball Valves:

1. 1/2" and 3/4": Brass body, UL listed, CSA approved for pressure of system, bronze ball valve, 175 WOG, with integral lever handle. Apollo #77F Series, Watts #FBV-1 or equal.
2. 1" thru 1-1/2": 175 psi working pressure, CSA and UL approved, bronze body, welded ends, stainless steel ball, stainless steel stem, steel handle with memory stop tab, conventional port. Apollo #77F-140 Series or equal.
3. Lubricated Plug Valve, 2" and Larger: Class 125, MSS SP-78, 200 PSI, UL listed, CSA approved for pressure of system, lubricated plug type, semi-steel body, loose wrench operated, straight way pattern round port, combination button head fitting and lubricant screw, Teflon seal and discs.

2.06 PIPING SPECIALTIES

A. General:

1. Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service or provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is installer's option.

B. Pipe Escutcheons:

1. Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas. Prime zinc base paint finish is allowed for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide stainless steel, cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide stainless steel escutcheons, solid or split hinged.

C. Unions:

1. Unions shall be of type specified in following schedule:
   a. Black Steel, 2" and smaller: 250 lb. screwed malleable iron, ground joint, brass to iron seat.
   b. Black Steel, 2-1/2" and larger: 150 lb. cast iron screwed flanged, flat faced, full faced gasket.
   c. Soldered Copper or Brass Pipe, 2" and smaller: 150 lb. cast bronze or copper, ground joint, non-ferrous seat with soldered ends.

d. Screwed Copper or Brass Pipe, 2" and smaller: 150 lb. cast brass, ground joint, brass to brass seat, with threaded ends.
e. Flanged Copper or Brass Pipe, 2-1/2" and larger: two (2) 150 lb. cast bronze flanges.

2. Manufacturers: EPCO, Mueller, Stanley G. Flagg, Watts, or equal.

D. Flanges:

1. Provide flanges at flanged connections to equipment, tanks and valves. Faces of flanges being connected shall be alike in all cases. Connection of raised-face flange to flat-faced flange not permitted.
2. Use ASTM A307, Grade B, bolts and nuts for cast iron flanges and ASTM A193 for steel flanges. Regular square head unfinished bolts with heavy semi-finished hex nuts ASTM A194. Cadmium plated where exposed to weather.
3. Ratings: 150 lb. or 300 lb. in high pressure portions.
4. Type of pipe and corresponding flanges as follows:
   a. Screwed Black Steel Pipelines: 125 lb. black cast iron screwed flange, flat faces.
   b. Welded Steel Pipe, 150 lb. black forges steel welding flanges, 1/16" raised face ASTM A181 Grade I. Use flat face when connected to flat faced companion flange.

E. Dielectric Fittings:

1. Dielectric Unions:
   a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
   b. Manufacturers: Watts #LF3000 Series, Zurn #DUX Series, or equal.

2. Dielectric Waterways/Nipples:
   a. Comply with standard IAPMO PS 66.
   b. Electroplated steel waterway/nipple complying with ASTM F1545 or ASTM F492.
   c. Pressure Rating: 300 psig (2070 kPa) at 225°F (107°C).
   d. End Connections: Male threaded or grooved.
   e. Lining: Inert and noncorrosive, propylene.
   f. Manufacturers: Mifab #MI-DE Series, Victaulic #Series 647, or equal.

3. Dielectric Flanges:
   a. Comply with standard ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 125 psig (860 kPa) minimum at 180°F (82°C).
   d. End Connections: Solder or brazed joint copper alloy and threaded ferrous; or threaded solder-joint copper alloy and threaded ferrous.
   e. Dielectric-Flange Insulating Kits:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Gasket: Neoprene or phenolic.
      3) Bolt Sleeves: Phenolic or polyethylene.
      4) Washers: Phenolic with steel backing washers.
   f. Manufacturers: Watts #LF3100 Series or equal.

F. Transition Couplings:

1. Coupling connection for grooved end AWWA ductile iron pipe to grooved end IPS stainless steel pipe, including valves or fittings of the same nominal size. Use grooved dielectric nipple for transition to copper tubing.
    a. Housing: Ductile iron conforming to ASTM A-536, grade 65-45-12 or ductile iron conforming to ASTM A-395, grade 65-45-15.
    b. Coating: Coal tar epoxy coating, 3 mils minimum thickness, for buried piping transition.
    c. Gasket: Grade "M" FlushSeal, halogenated butyl (brown color code). Temperature range –20°F to +200°F (–29°C to 93°C). Specially compounded to conform to ductile pipe surfaces. UL classified in accordance with ANSI/NSF 61 for cold potable water service.
    d. Bolts/Nuts: Heat-treated plated carbon steel or stainless steel 316 for buried applications, compliant with the physical and chemical requirements of ASTM A-449 and physical requirements of ASTM A-183.
    e. Manufacturers: Victaulic #Style 307 or equal.

G. Pipe Sleeves:

1. Provide fire proof sleeve assemblies utilizing UL rated sealant systems at all fire rated penetrations. For non-rated sleeve penetrations pack the annular space between the pipe and sleeve with fiberglass and/or mastic.
2. Sleeves shall provide a minimum 1/2" annular clearance around pipe. Where pipes cross through footings or footing walls provide a minimum 1" annular clearance between sleeve and pipe.
3. Sheet metal: Fabricate from 0.025" (0.64 mm) minimum, sheet metal; round tube closed with snap lock joint, welded spiral seams, or welded longitudinal joint.
4. Steel pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
5. Iron pipe: Fabricate from cast iron or ductile-iron pipe; remove burrs.
6. Plastic and copper pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.
7. Sleeves through interior concrete walls and floors: Telescopic, submerged, adjustable sleeves to extend a minimum of 1" above finished floor. Manufacturers: Adjust-to-Crete, Crete-Sleeve, Hilti, or equal.
8. Through exterior walls and floor on grade: 150-pound class cast-iron pipe sleeve. Where waterproof membranes are used, provide membrane clamps. For insulated piping, sleeve diameter shall not be less than diameter of insulated pipe.
9. Cast-in-place watertight device for protecting penetrating objects from expansion and contraction of concrete. Factory-assembled for use in cast-in-place concrete floors and walls and consisting of two outer sleeves and a one-piece radial extended-flange waterstop gasket, with mid-body seal for embedment and sealing to concrete slab and continuous water seal extending to the penetrating pipe.
    a. Outer Sleeves: EPDM attached to the mid-body seal forming an area with which to attach the device to the structural reinforcing rod determining the position of sleeve in the wall.
    b. Water Stop Mid-Body Seal: Flexible polymer seal with radial extended flange consisting of one to three concentric raised rings which lock into concrete, maintaining seal over time as concrete contracts from sleeve.
    c. Manufacturers: HoldRite #HydroFlame, or equal.

2.07 GAS CONNECTORS

A. Gas connectors for outdoor applications shall be listed for exterior use.

PART 3 - EXECUTION

3.01 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install water piping and fixtures uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work, unless so indicated on Drawings or approved by Architect or Owner's Representative.

C. Pipe showing rust or cracks in coating shall be removed and replaced.

D. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

E. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions of the work or contracts toward rapid completion of the entire project. If any cooperative work must be altered due to lack of proper supervision or failure to make proper provisions in time, then the work hereunder shall include all expenses of such changes as are necessary in the work under other contracts, and such changes shall be directly supervised by and made to the satisfaction of the Owner's Representative.

F. The cooperative work not included in the Plumbing Division related to the general construction work is as follows:

1. All formed concrete work.
2. Framed openings in masonry and other Architectural and Structural elements.
3. Wood grounds and nailing strips in masonry and concrete.
4. Sloping of floors to drains and floor sinks.
5. Sloping of roof surfaces to roof drains and overflow drains.

G. Inspect all material, equipment, and apparatus upon delivery and do not install any that may be subject to rejection as a result of damage or other defects. Provide tarps (waterproof membrane) to protect equipment and piping delivered to and stored at the site.

H. Piping in connection with a plumbing system shall be so installed that piping or connections will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction, and structural settlement. No plumbing piping shall be directly installed or embedded in concrete or masonry. No structural member shall be seriously weakened or impaired by cutting or notching. Sleeves, sealants and/or gasketing shall be utilized where penetrating through concrete or masonry assemblies.

I. All backflow preventers require adequate access clearance for future testing and maintenance. The backflow prevention device shall be installed with not less than 12 inches of clearance between the lowest portion of the assembly and grade, floor or platform. Installation of backflow prevention devices mounted more than five (5) feet above the floor shall be provided with a permanent platform capable of supporting a tester or maintenance person. The measurement is taken from the centerline of the device to the floor or platform.

J. Install engineered siphonic drain specialties and storm drainage piping in locations indicated.

3.02 PIPES SIZES TO EQUIPMENT

A. General: Pipe sizes indicated shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of equipment.

B. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valve.

3.03 PIPING INSTALLATION

A. Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints or couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" misalignment tolerance. Comply with ASME B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details, and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation. Whenever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as indicated.

C. Where vents connect to a horizontal drainage pipe, each vent shall have its invert taken off above the drainage centerline of such pipe downstream of the trap being serve. Each vent shall rise vertically to a point not less than 6” above the flood-level rim of the fixture served before offsetting horizontally.

D. Fuel Gas Requirements:

1. Ball valves used in gas systems shall be UL listed, CSA approved for pressure of system, no exception.
2. Provide gas meter and sub-meters as required by the local servicing utility, code and where shown on drawings. Provide shut-off valves at inlet and outlet side of each meter. Coordinate communications wiring and programming with BAS and local gas utility as required.
3. Gas pressure regulator requirements:
    a. Provide access to each pressure regulator.
    b. Where regulators are located indoors, the regulator shall be vented to the outdoors or shall be equipped with a leak-limiting device.
    c. Provide shutoff valve upstream of each regulator and test tees.
    d. Provide a tee fitting with one opening capped or plugged located between the regulator and its upstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument.

e. Provide a tee fitting with one opening capped or plugged installed not less than ten (10) pipe diameters downstream of the regulator outlet.
f. Provide a tee fitting with one opening capped or plugged located downstream of the downstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument to verify gas pressure available to gas appliance.

3.04 SLEEVE INSTALLATION

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

B. Install sleeves in concrete floors, concrete roof slabs, and concrete/masonry walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2” (50 mm) minimum above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

C. Install sleeves for pipes passing through fire rated interior partitions as required by assembly construction.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4” (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
4. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping." Exception: When fire-resistance-rated cast-in-place watertight sleeve seals are required for floor penetrations, additional firestopping is not necessary.

3.05 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

C. Aboveground, Cast-in-Place Watertight Sleeves. Select sleeve size based on pipe size and material to be inserted, and thickness of wall.

1. Install cast-in-place watertight sleeves for pipes NPS 6" (DN 150) and smaller in diameter.
2. Position cast-in-place watertight sleeve in wall space securing sleeve to reinforcing steel using tie wire.

D. Fire-Resistance Rated, Cast-in-Place Sleeve Installation: Select sleeve size based on size and type of pipe and thickness of the floor. Position and secure sleeve to concrete form using nails or staples.

3.06 PIPING SYSTEM JOINTS

A. All piping shall be cut squarely, free of rough edges/burrs, and reamed to full bore. Piping shall be mechanically cleaned prior to make-up of joints and fully inserted into fittings. Bevel plain ends of steel pipe.

B. Piping shall be capped during construction to prevent entry of foreign material.

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

D. Provide joints of type indicated in each piping system and as required to meet the maximum allowable working pressure and maximum testing pressures.

E. Thread pipe in accordance with ANSI/ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Remove excess cutting oil from piping prior to assembly.

1. Apply appropriate (Teflon) tape or thread compound to external pipe threads. on male threads at each joint and tighten joint to leave not more than three (3) threads exposed.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Soldered and brazed copper water tube and fittings: Comply with maximum allowable rated internal working pressures as defined in ASME B31.9, and matching table in ASHRAE Handbook-HVAC Systems and Equipment, based on maximum service temperature and pipe diameter. Soldered and brazed joints shall only be installed where complete access is available on all sides of the pipe to assure that visual inspection can occur for 360° circumference. Blind soldering or brazing is not allowed, in such cases the use of mechanical type fittings shall be utilized. This would apply to situations such as pipes attach tight to floor or ceiling/roof requiring mechanical type joints.

ASME B31.9-2008 Table 917.3
Rated Internal Working Pressure of Joints Made With
Copper Water Tube and Solder Joint Fittings (psig)

Solder or Brazing	Maximum Service Temperature (°F)	Types K, L, M Copper Water Tube in Nominal Sizes (inches) Liquids and Gases			
		1/4" to 1"	1-1/4" to 2"	2-1/2" to 4"	Up to 8"
Tin Alloys ASTM B32	100	500	400	300	270
	150	400	350	275	250
	200	300	250	200	180

	250	200	175	150	135
Brazing Alloys	200	Tube Rating	Tube Rating	Tube Rating	Tube Rating
	250	300	210	170	150
	350	270	190	150	150

G. Solder copper tube and fitting joints with lead free nickel/silver bearing solder meeting ASTM B-32, in accordance with plumbing code requirements, ASTM B828 and Copper Development Association (CDA) recommended procedures. Joints shall be cleaned by other than chemical means prior to assembly. "Shock" cooling is prohibited. Fluxes shall be applied liberally to the outside of the pipe and the solder cup of the fitting. Fluxes shall be water soluble for copper and brass potable water applications and shall meet CDA standard test method 1.0 and ASTM B813. Solder shall be applied until a full fillet is present around the joint. Solder and flux shall not be applied in such excessive quantities as to run down interior of pipe. Lead solder or corrosive flux shall not be present at the jobsite.

H. Braze copper tube and fitting socket or mechanically formed tee fittings with BCUP series filler metal without flux. Listed brazing flux shall be used for joining of copper tube to brass or bronze fittings and shall meet AWS FB3A or FB3C. "Shock" cooling is prohibited. A continuous fillet shall be visible around the completed joint. After cooling, flux residue shall be thoroughly removed with warm water and a brush prior to testing. Do not use BCUP filler on copper alloys containing over 10% nickel.

1. Brazing fittings may use a mechanically limited depth that is not less than the minimum cup depth (overlap) specified by ANSI/ASME B16.50 for Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings. Manufacturer of mechanical dimpler: Brazing Dimpler Corp or equal.

I. Depth of solder joint and braze joint fitting:

Depth of Solder Joint and Braze Joint Fittings		
Pipe Size (inches)	ASME 16.22 Solder Joint Socket Depth (inches)	ASME B16.50 Brazed Joint Socket Depth (inches)
1/2	0.50	0.22
3/4	0.62	0.25
1	0.75	0.28
1-1/4	0.97	0.31
1-1/2	1.09	0.34
2	1.34	0.40
2-1/2	1.47	0.47
3	1.66	0.53
4	2.16	0.64
5	2.66	0.73
6	3.09	0.83
8	4.09	1.28

J. Cast-Iron Sanitary Sewer Joints: Comply with coupling manufacturer's Cast Iron Soil Pipe Institute Standards and installation instructions.

K. 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. Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

L. Weld pipe joints in accordance with recommendations of American Welding Society AWS D1.1 and ASME Boiler and Pressure Vessel Code Section IX.

1. Weld pipe joints only when ambient temperature is above 0°F.
2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
3. Use pipe clamps or tack-weld joints with 1" long welds, 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" and larger.
4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and at edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
5. Do not weld out piping system imperfections by tack-welding procedures. Refabricate to comply with requirements.
6. At Installer's option, install forged branch-connection fittings whenever branch pipe is indicated, or install regular T-fitting.

3.07 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping Outside of Building Footprint:

1. Fittings for NPS 1-1/2” (DN 40) and Smaller: Fitting-type coupling.
2. Fittings for NPS 2” (DN 50) and Larger: Sleeve-type coupling or grooved type fitting.

C. Transition Fittings in Aboveground Domestic Water Piping: Unions, flanges, grooved fittings, or connect to isolation valve to meet field conditions and maintain pressure testing requirements.

3.08 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing such as copper to zinc plated equipment fittings or copper to galvanized steel or black steel equipment.

1. Dielectric Fittings for NPS 2” (DN 50)] and Smaller: Use dielectric couplings, nipples, unions.
2. Dielectric Fittings for NPS 2-1/2” to NPS 4” (DN 65 to DN 100): Use dielectric flange kits or threaded nipples.
3. Dielectric Fittings for NPS 5” (DN 125) and Larger: Use dielectric flange kits.

B. Dielectric couplings are not required in the following locations:

1. Unions in a copper piping system with connections to brass/bronze valves and devices.
2. Unions in a copper piping system with connections to stainless steel valves and devices.
3. Connections to water hammer arrestors.

3.09 VALVES

A. General: Except as otherwise indicated, comply with the following requirements:

1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves to be accessible. Provided separate support as necessary.
2. Install valves, except butterfly valves, with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane without prior written approval. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends of types of pipe/tube connections:

1. Copper Pipe, 2-1/2" and Smaller: Soldered-joint valves.
2. Steel Pipe, 2" and Smaller: Threaded joint valves.
3. Larger Pipe Sizes: One of the following, at installer's option:
   a. Flanged valves.
   b. Lug valves.

D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

F. Fluid Control: Except as otherwise indicated, install gate, ball, plug, circuit setter, globe, and butterfly valves to comply with ASME B31.9.

G. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

H. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

I. Valve Identification: Tag each valve in accordance with Section 220500.

J. Cleaning: Clean factory-finished surfaces. Repair marred or scratched surfaces with manufacturer's touch-up paint.

3.10 SUPPORTS AND HANGERS

A. Refer to Section 220500 – Basic Plumbing Materials and Methods.

3.11 EQUIPMENT RAILS AND PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed.

C. Verify roof insulation thickness and adjust raise of cant to match.

3.12 PIPE INSPECTIONS

A. Inspections shall be performed at each phase while under tests required for administrative authorities, and prior to concealment, i.e. "rough-in", "top-out" and "final".

B. Inspection – Underground: All piping installed underground shall be inspected prior to burial by the Owner's Representative. Contractor must notify Owner's Representative no less than 24 working hours prior to inspection time. Should the piping be buried prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

C. Inspection – Aboveground: All piping installed Aboveground shall be made available for inspection upon completion and prior to finish of walls and ceilings. Contractor must notify Owner's Representative no less than 24 working hours prior to the desired inspection time. Should the piping be hidden within the structure prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

3.13 CLEANING, FLUSHING, DISINFECTING

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any).

B. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports, and accessory items.

C. Inspect pressure piping in accordance with procedures of ASME B31.

D. Disinfect water mains and water service piping in accordance with Section 220500.

3.14 TESTING

A. Provide all tests specified hereinafter. All tests shall meet or exceed the minimum requirements of applicable codes and local ordinances. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Architect, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Piping: Remove from the system, during testing, all equipment which would be damaged by test pressure. Replace removed equipment when testing has been accomplished. The system may be tested in sections as the work progresses; however, any previously tested portion shall

become a part of any latter test of a composite system. Correct leaks by remaking joints with new material.

C. Test time will be accrued only while full test pressure is on the system, unless indicated otherwise. "Tolerance" shall be no pressure drop, except that due to temperature change in a 24-hour period. Inspect and test all work prior to burying or concealing. Test pressure shall be one and one-half times the system operating pressure or the listed test pressure below, whichever is greater:

System	Test Medium	Test Pressure	Tolerance-Test Period
Domestic Water	Water	150 psig	None – 8 hours
Sanitary Sewer and Gravity Condensate (non-plastic)	Water	10 ft head (or 5 psi air)	No leaks – 8 hours
Sanitary Sewer and Gravity Condensate (plastic)	Water	10 ft head	No leaks – 8 hours
Vent (non-plastic)	Air	5 psi	No leaks – 8 hours
Vent (plastic or non-plastic)	Water	10 ft head	No leaks – 8 hours
Rainwater	Water	10 ft head (or 5 psi air)	No leaks – 8 hours

D. Valves: Test all valve bonnets for tightness. Test operate all valves at least once from closed-to-open-to-closed position while valve is under test pressure. Test all automatic valves, including solenoid valves, and temperature and pressure relief valves, safety valves, and temperature and pressure relief valves not less than three (3) times.

END OF SECTION 221000

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this section shall include, but not necessarily be limited to, the installation of plumbing fixtures and trim.

1.03 RELATED WORK IN OTHER SECTIONS

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 223000: Plumbing Equipment

1.04 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer's data, colors, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:

1. Plumbing fixtures.
2. Piping specialties.
3. Roof drains.

B. Shop Drawings: Submit rough-in drawings. Detail dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages. Coordinate requirements with Architectural Woodwork shop drawings specified in Division 06 for fixtures installed in countertops and cabinets. Furnish templates for use in woodwork shop.

C. Samples: Submit samples of any piece of equipment requested by Architect for review and approval.

D. Wiring Diagrams: Submit manufacturer's electrical requirements and wiring diagrams for power supply to units. Clearly differentiate between portions of wiring that are factory installed and field installed portions.

1.05 CODES AND STANDARDS

A. Applicable Plumbing Code with State Amendments.

B. All fixtures and accessories must be approved for use by the State and local jurisdictions.

C. All fixtures and faucets must meet all requirements of Americans with Disabilities Act (ADA).

D. State Energy Code

E. NSF/ANSI 16: This Standard is intended to cover specific materials or products that come into contact with drinking water, drinking water treatment chemicals, or both. The focus of the Standard is evaluation of contaminants or impurities imparted indirectly to drinking water. The products and materials covered include, but are not limited to, process media, protective materials, joining and sealing materials (cements, solders, gaskets), pipes and related products, mechanical devices and plumbing devices such as fixtures and valves.

F. NSF 372: Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining "weighted average".

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged products. Remove damaged products from project site.

1.07 MAINTENANCE

A. Extra Stock:

1. Furnish special wrenches and other devices necessary for servicing plumbing fixtures, flush valves, and trim to Owner's Representative with receipt in a quantity of one device for each 10 fixtures.

1.08 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide fixtures as specified. Fixtures in any secure or public areas shall be vandal proofed.

B. Architect/Engineer shall review and approve any substitution requested by Contractor prior to bid submittal.

2.02 LISTING

A. Refer to plumbing fixture schedule on drawings for manufacturers, model numbers and selection criteria.

PART 3 - EXECUTION

3.01 GENERAL

A. Verify all dimensions by field measurements. Verify that all plumbing fixtures may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Examine rough-in for potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.

C. Examine walls, floors and cabinets for suitable conditions where fixtures are to be installed.

D. Install plumbing fixtures level and plumb, in accordance with fixture manufacturer's written instructions, rough-in drawings, and pertinent codes and regulations, the original design, and the referenced standards.

E. Comply with the installation requirements of ADA with respect to plumbing fixtures for the physically handicapped.

F. Fasten plumbing fixtures securely to supports behind wall or building structure. Secure supplies behind or within wall construction to provide rigid installation.

G. Install a stop valve in an accessible location in the water connection to each fixture.

H. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork.

I. Seal fixtures to walls and floors using sealants as specified in Division 07. Match sealant color to fixture color.

J. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, then retest.

K. Inspect each installed unit for damage. Replace damaged fixtures.

L. Replace washers or cartridges of leaking or dripping faucets and stops.

M. Clean fixtures, trim, and strainers using manufacturer's recommended cleaning methods and materials.

END OF SECTION 224000

SECTION 230500 - BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and shall include all Mechanical Sections specified herein.

1.02 SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Compliance with all codes and standards applicable to this jurisdiction
2. Shop Drawings for Equipment
3. Coordination Documents
4. Record Drawings
5. Start-up Service and Building Commissioning
6. Instruction, Maintenance, and O & M Manuals
7. Work associated with Delivery, Storage, and Handling of products
8. Work associated with provision of Temporary Facilities
9. Preparation of Posted Operating Instructions
10. Meeting Project Safety and Indemnity requirements
11. Proper Cleaning and Closing
12. Supplying proper Warranty information
13. Supply specified Guarantee documentation
14. Design and provision of Supports and Anchors
15. Equipment Rails
16. Access Doors
17. Identification Markers
18. Coordination of Electrical requirements for equipment provided

1.03 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide all material and labor to install complete heating, ventilating, air conditioning systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate this work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, duct routing and pipe routing and are not to be scaled. All dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and site systems, every effort has been made to note existing utilities and services. However, the Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all mechanical system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The mechanical system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply mechanical devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with ductwork and piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

1.04 DESCRIPTION OF BID DOCUMENTS

A. Specifications:

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:

1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation.
2. Before proceeding with work check and verify all dimensions.
3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
4. Make adjustments that may be necessary or requested, in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
5. Where existing pipes, conduits and/or ducts prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits and/or ducts. Verify exact location and elevation of existing piping prior to any construction.
6. If any part of Specifications or Drawings appears unclear or contradictory, apply to Owner’s Representative interpretation and decision as early as possible, including during bidding period.

1.05 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Accessible: Ability to perform recommended maintenance without removal of services or equipment and requiring no special platforms.

C. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

D. Below Grade: Buried in the ground or embedded in concrete slab on ground.

E. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

F. Connect: Complete hook-up of item with required service.

G. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

H. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements.

I. Explosion Proof Equipment (per National Electrical Code-Article 501): Equipment enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby. Explosion proof motors are required for Class I, II or II applications regardless of Division or Group as defined in National Electrical Code – Article 501 and ANSI/ISA-12.20.01.

    1. Class I: Hazardous due to flammable gases or vapors are present or may be present in quantities sufficient to produce explosive or ignitable mixtures.
    2. Class II: Hazardous due to combustible or conductive dusts are present or may be present in quantities sufficient to produce explosive or ignitable mixture.
    3. Class III: Hazardous dues to ignitable fibers are present or may be present in quantities sufficient to produce explosive or ignitable mixtures.
    4. Division: The substance referred to by Class has a high probability (Division 1) or low probability (Division 2) of producing an explosive or ignitable mixture due to it being present continuously, intermittently, or periodically or from the equipment itself under normal operating conditions.
    5. Group: Type of hazardous material in surrounding environment ranging from Group A flammable liquids to Group G combustible dusts.

J. Exposed: Not installed underground or concealed.

K. FRT: Fire retardant treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84 or UL 723, a listed flame spread index of 25 or less.

L. Furnish: To supply equipment and products as specified.

M. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

N. Install: To erect, mount and connect complete with related accessories.

O. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

P. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

Q. Noncombustible Material: A noncombustible material is a substance that will not ignite, burn, support combustion, or release flammable vapors when subject to fire or heat in compliance with ASTM E136 Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C. Examples of noncombustible materials include the following, but confirm compliance in manufacturer literature:

1. Portland cement concrete, concrete, gypsum concrete (normally used in drywall or poured gypsum floor toppings), Portland cement stucco, Portland cement plaster, and gypsum plaster, gypsum wall board (sheetrock), and Type X gypsum wall board.
2. Brick masonry, concrete block masonry, and ceramic tiles.
3. Steel, stainless steel, galvanized steel, and other metals, except aluminum (aluminum is classified as limited-combustible), magnesium and magnesium alloys.
4. Sheet glass, block glass, and uncoated glass fibers.
5. Mineral wool and rock wool.

R. NRTL: Nationally Recognized Testing Laboratory, including UL and/or ETL.

S. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

T. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

U. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

V. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

W. Shall: An exhortation or command to complete the specified task including providing and installing work associated with task.

X. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

Y. Supply: To purchase, procure, acquire and deliver complete with related accessories.

Z. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

AA. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall".

BB. Wiring: Raceway, fittings, wire, boxes and related items.

CC. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.06 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 23 Mechanical sections included herein.

B. Division 03: Concrete.

1. All concrete work required for mechanical work shall be coordinated by Division 23 with Division 03 including:
   a. Concrete curbs and housekeeping pads for the mechanical equipment.
   b. Thrust blocks, pads, and boxes for mechanical equipment.

C. Division 07: Thermal and Moisture Protection.

1. Flashing and sheet metal.
2. Sealants and caulking.
3. Firestopping.

D. Division 09: Painting.

1. Division 23 shall coordinate with Division 09 to perform all painting, except where specifically stated otherwise in Division 09.
2. Painting of all exposed steel, piping, ductwork, insulation, equipment and materials
3. Paint all exposed gas piping, interior and exterior to the building, yellow.

E. Division 26: Electrical.

1. Power connections to all mechanical equipment

F. Division 28: Electronic Safety and Security.

1. Fire protection alarms and relays.
2. Smoke detector and monitoring.
3. Life safety systems.

1.07 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 23 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All accessible mechanical work shall comply with the minimum requirements of the Americans with Disabilities Act (ADA) and local amendments. Also, refer to ICC/ANSI A117.1 Accessible

and Usable Buildings and Facilities. Refer to Architectural drawings and specifications for additional ADA requirements. The following requirements are provided as consolidated list of minimum ADA requirements. Compliance requirements applicable to HVAC work includes, but is not limited to, the following:

1. Section 309: Operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be 5 pounds maximum.
2. Section 308.3: Temperature control devices mounted on walls with operable buttons or switches shall be placed where clear floor or ground space allows a parallel approach and the side reach is unobstructed. Operable parts shall be located 48" maximum above finished floor, and no lower than 42" above finished floor. Do not mount above light switches to avoid inaccurate temperature readings due to light switch heat output.
3. Section 308.3.2: Where a clear floor or ground space allows a parallel approach to an element and high reach is over an obstruction, the height of the obstruction shall be 34" maximum and depth of obstruction shall be 24" maximum.
4. Section 404.2.9: Fire doors shall have a minimum opening force allowable by the applicable Building Code. The force for pushing or pulling open a door other than fire doors shall be 5 pounds maximum.

E. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

F. Provide in accordance with rules and regulations of the following:

1. Oregon Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2019 Oregon Structural Specialty Code (OSSC) based on 2018 International Building Code (IBC).
   b. 2021 Oregon Energy Efficiency Code (OEESC) based on the 2018 International Energy Conservation Code (IECC).
   c. 2019 Oregon Mechanical Specialty Code (OMSC) based on 2018 International Mechanical Code (IMC) and 2018 International Fuel Gas Code (IFGC) with State Amendments.
   d. 2021 Oregon Plumbing Code (OPC) based on 2021 Uniform Plumbing Code (UPC) with State Amendments.
   e. 2019 Oregon Fire Code (Based on the 2018 International Fire Code.)
   f. 2017 Oregon Electric Specialty Code (Based on the 2017 National Electric Code (NEC) with State Amendments.
2. Local, city, county and state codes and ordinances.
3. Local Bureau of Buildings.
4. Local Health Department.
5. Local and State Fire Prevention Districts.
6. State Administrative Codes.
7. Latest edition of OSU Construction Standards

G. Provide in accordance with appropriate referenced standards of the following and as referenced in other specification sections:

1. AABC - Associated Air Balance Council
2. ADA - Americans with Disabilities Act
3. ADC - Air Diffuser Council

4. AHRI - Air Conditioning, Heating and Refrigeration Institute
5. AMCA - Air Moving and Conditioning Association
6. ANSI - American National Standards Institute
7. ASCE 7-10 – American Society of Civil Engineers – Minimum Design Loads for Buildings and Other Structures
8. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers
9. ASME - American Society of Mechanical Engineers
10. ASTM - American Society for Testing Materials
11. AWS - American Welding Society
12. CSA - Canadian Standards Association
13. ETL - Electrical Testing Laboratories
14. FM - Factory Mutual
15. IBC - International Building Code
16. ICC AC156 Seismic Certification by Shake-Table Testing of Nonstructural Components.
17. MSS - Manufacturer's Standardization Society
18. NEMA - National Electrical Manufacturer's Association
19. NFPA - National Fire Protection Association
20. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
21. UL - Underwriter's Laboratories

1.08 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner’s Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Owner’s Representative for a decision before proceeding.

1.09 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be metallic riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data suitable for the ambient exposure.

B. All work shall include the following:

1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 23, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Each product and/or equipment type shall be provided by one manufacturer. Mixtures of manufacturers for each product and/or equipment type are not acceptable. Example – all fire dampers shall be supplied by one manufacturer.

E. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

F. Welding Standards:

1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The welder must maintain their certification to show qualified welding experience every six months. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1.10 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permit, licenses, fees and inspections, including, but not limited to, building permits, planning permits, air quality management district permits, operating licenses, utility district fees, special district fees, environmental impact reports, and additional local permits and fees.

D. Prepare a Construction IAQ Management Plan meeting the SMACNA IAQ guidelines. See Section 233113 Air Distribution for a summary of requirements.

E. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access. Joints and fittings shall not be located in inaccessible locations such wall, floor and roof penetrations.

F. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to Equipment Specifications for rough-in requirements.

G. Coordinate mechanical equipment and materials installation with other building components.

H. Ductwork dimensions, as identified on drawings and in specifications, refer to the interior free dimensions. Adjust work as necessary to account for larger outside dimensions to account for material wall thickness.

I. Verify all dimensions by field measurements.

J. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.

K. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

L. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

M. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor shall provide for all cutting and patching required for installation of this work unless otherwise noted.

N. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

O. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

P. Coordinate the installation of mechanical materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

Q. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

R. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

S. All materials (such as supports, gaskets, sealants, insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall be noncombustible or have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Coordinate with

all disciplines to assure that all discrete electrical, plumbing and mechanical products located in plenums are non-combustible and compliant with UL 2043.

T. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.11 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all mechanical work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting their work. It is the specific intention of this section that the contractor's scope of work shall include:

C. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

D. Minor deviations from the mechanical plans required by architectural and structural coordination.

E. The Contractor shall study the operational requirements of each system, and shall arrange work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work". Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

F. Minor deviations to avoid conflict shall be permitted where the design intent is not altered.

G. Advise the Owner's Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

1.12 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Delegated-Design Submittal: For structural equipment supports, 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 preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic, and where required wind forces required to select vibration isolators, seismic and wind restrains, support framing members, and for deigning vibration isolation bases.
2. 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. Provide base with level top surfaces with integral sloping on bottom to match support structure.

E. Submittals and Shop Drawings:

1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
3. Paper submittals will only be acceptable if specifically required by Division 01.
4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.13 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.

1. The shop drawings shall serve to record the coordination of the installation and location of all HVAC equipment, ductwork, grilles, diffusers, piping, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
2. The Drawings shall include all mechanical rooms and floor plans.
3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.
4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:

1. Two dimensional AutoCAD / Revit based documents:
   a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
   b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.
   c. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   d. Drawings shall incorporate all addenda items and change orders.
   e. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

2. Three dimensional Revit / BIM based documents (if required for project):
   a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Model shall incorporate all addenda items and change orders.
   f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

F. Provide copy of Record Drawings to Testing and Balancing Contractor for their use when doing their work.

1.14 REQUESTS FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).

1. Coordinate and submit each RFI in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
2. Each RFI shall address single questions and related issues only.
3. Each RFI shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect and/or Construction Manager.
6. RFI number, numbered sequentially and unique.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response to each RFI, plus additional time for Architect and General Contractor to review and forward. Each RFI received by Engineer after 1:00 p.m. will be considered as received the following business day.

1. The following Contractor-generated RFIs will be returned without action:
    a. Incomplete RFIs or inaccurately prepared RFIs.
    b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
    c. RFIs addressing multiple unrelated issues.
    d. Requests for approval of submittals.
    e. Requests for approval of substitutions.
    f. Requests for approval of Contractor's means and methods.
    g. Requests for information already indicated in the Contract Documents.
    h. Requests for adjustments in the Contract Time or the Contract Sum.
    i. Requests for interpretation of Engineer's actions on submittals.

2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.15 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked "Record Set" at the job site at all times and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. Provide copy of Record Documents to Testing and Balancing Contractor and Commissioning Agent for use when performing their work.

E. At the completion of the construction transfer all "Record Set" notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

F. Refer also to Division 01 for full scope of requirements.

1.16 START-UP SERVICE AND BUILDING COMMISSIONING

A. Prior to start-up, be assured that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of air conditioning units, temperature controls, chillers, boilers, pumps, and other major pieces of equipment. Certify in writing compliance with this Paragraph, stating names of personnel involved and the date work was performed.

C. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

D. Refer to other Division 23 Sections for additional requirements.

1.17 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. Operations and Maintenance (O&M) Manuals: Upon completion of the work, and prior to training of Owner's personnel, the Contractor shall submit to the Owner's Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section, bound in a durable binder. Refer to Division 01.

B. Contractor shall be responsible for providing proper instruction of the of Owner's personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 23. Training is to be appropriate to the complexity of the equipment. The Contractor shall develop and submit training materials prior to this training. These materials shall include qualifications of the trainer, training agenda, learning objectives, and a written test to be administered at the end of the training session. Operation and Maintenance manuals must present, incorporated and referenced in the training sessions.

1.18 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

1.19 UNIT PRICING SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. Preliminary List of Materials and Unit Price Items: Within thirty (30) days after awarding of the Contract, submit to Owner and Owner's Representative for preliminary approval a complete list of manufacturer's names and model numbers of proposed materials and equipment. Also include proposed list of unit price items for review.

1. Indicate substituted items.
2. Identify test and balancing agency.
3. Identify independent testing laboratory for water analysis.

C. The Contractor shall submit with preliminary list of materials a unit price list for each item furnished on this project. Included with price shall be labor cost index.

D. Submittals and Shop Drawings shall be submitted as a complete package bound in a 3-ring binder with tabs for each specification section. Submit six (6) typed copies of submittals. Refer to Division 01 for additional requirements.

1.20 TEMPORARY FACILITIES

A. Refer to Division 01 for the requirements of temporary water and sewer for construction and safety. Provide temporary heating, air conditioning, ventilation, water, and sewer, etc. services as necessary during the construction period and as required to maintain operation of existing systems.

B. Temporary Heating for Commissioning Tests:

1. Provide temporary heating where needed to provide false load for commissioning tests.
2. Temporary heating may be from the permanent heating system of the project or from a dedicated temporary heating system. If temporary system is necessary, select facilities known to be safe and without deleterious effect upon what work in place or being installed.

C. Temporary Cooling for Commissioning Tests:

1. Provide temporary cooling where needed to provide false load for commissioning tests.
2. Temporary cooling may be from the permanent cooling system of the project or from a dedicated temporary cooling system. If temporary system is necessary, select facilities known to be safe and without deleterious effect upon the work in place or being installed.

1.21 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.22 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner’s Representative, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of,

or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner's Representative, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.23 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner's Representative.

1.24 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.25 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after Substantial Completion, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

2.02 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:

1. UL and FM Compliance: Provide products, which are UL listed and FM approved.
2. ASCE 7 (Latest Edition): American Society of Civil Engineers-Minimum Design Loads for Buildings and Other Structures.
3. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
4. SMACNA: Seismic Restraint Manual: Guidelines for Mechanical Systems.
5. NFPA: Pamphlet number 13 and 14 for fire protection systems.
6. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.
7. Manufacturer: Mason Industries, Hilti Inc., B-Line/Tolco (Eaton), Anvil, Erico, Kin-Line, Simpson Strong-Tie Co. Inc., Superstrut, Empire, PHD Manufacturing, Carpenter & Paterson, Powers Fasteners or equal

B. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.

1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

C. Building Attachments: Except as otherwise indicated by the Structural Engineering design, provide factory-fabricated building attachments of one of the following types listed.

1. Concrete Inserts:
   a. MSS Type 18.
   b. Manufacturers: Hilti #KCS-MD (for metal deck) or HCI-WF (for wood forms), Simpson Strong Tie #Blue Banger Hanger, Powers Fasteners #Bang-It (for metal deck) or #Wood-Knocker (for wood forms), or equal.

2. Steel Brackets: One of the following for indicated loading:
   a. Light Duty: MSS Type 31.
   b. Medium Duty: MSS Type 32.
   c. Heavy Duty: MSS Type 33.

3. Horizontal Travelers: MSS Type 58.
4. Concrete Screw Anchors: For floor mounted attachments with maximum allowable pullout and shear force of 250 lbs. (1.1 kN) per anchor regardless of size.
   a. Manufacturers: Hilti #Kwik Hus EZ-I, Simpson Strong-Tie #Titen HD (or Rod Hanger version), Powers Fasteners #Wedge-Bolt+ (Screw Anchor), Powers Fasteners #Vertigo+ (Rod Hanger), Powers Fasteners #Snake+ (Internally Threaded Screw Anchor), or equal.

5. Torque-Controlled Expansion Anchor:
   a. Manufacturers: Hilti #Kwik Bolt TZ2, Simpson Strong Tie #Strong-Bolt 2, Powers Fasteners #Power-Stud+ SD1 or Power-Stud+ SD2, or equal.

6. Screws and Bolts:
   a. Manufacturers: Bolt Depot, Fastenal, National Bolt & Nut, or equal.

7. Eye Bolts:
   a. Manufacturers: Lawson Products, Sierra Pacific, US Cargo Control, or equal.

8. Powder-Driven Concrete Anchors:
   a. Only for existing concrete structures with minimum 4000 psi concrete compressive strength.
   b. Minimum embedment of 1” (25 mm).
   c. Maximum allowable load of 50 lbs. (0.2 kN) per anchor.
   d. Manufacturer: Hilti #X or D Series, Powers Fasteners #CSI Series, or equal.

D. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping at hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with adjacent pipe insulation. Insulation shall be continuous through each support with no direct contact between pipes and support elements wherever pipes are required to be insulated.

1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
2. Insulation Protection Shields: MSS Type 40, 18" minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of

same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert.
   a. Pre-manufactured insulated pipe shields are an acceptable alternate when installed per manufacturer's instructions for pipe sizes to 6" diameter. Manufacturers: SnappItz, Armacell #ArmaFix Ecolight or equal.

4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain un-insulated tubing at clevis hangers and strut-mounted clamps. Allowed for pipe diameter up to 4".
   a. Manufacturers: Hydra-Zorb #Klo-Shure Insulation Couplings, Mason Industries #MW-SCCI or equal.

E. Miscellaneous Materials:

1. Metal Framing: Provide products complying with NEMA STD ML1.
2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of one-part cement to three-parts sand by volume, with minimum amount of water required for placement and hydration.
4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
5. Pipe Brackets: Copper plated brackets and supports for various mounting options. Insulate brackets attached to metal studs with felt.
   a. Manufacturers: Holdrite or equal.

2.03 EQUIPMENT RAILS

A. Where equipment rails are not provided by other sections of Specification, provide prefabricated reinforced equipment rails as required for support of equipment. Field built curbs are acceptable alternatives - provide detail of construction for review.

B. Standard equipment rail, unless otherwise noted, shall be constructed as follows:

1. Construct of heavy gauge galvanized steel with continuous welds on shell seams.
2. Provide internal reinforcing supports welded as required to meet application requirements.
3. Equipment rails to have raised 3" (minimum), 45° cant.
4. Equipment rails to have 1-1/2" x 1-1/2" wood nailer (minimum) and counterflashing.
5. Equipment rail height to be 6" (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.

C. Equipment rails to be constructed to meet equipment size and weight requirements. Provide tapered rails to match roof pitch where required. Coordinate with structural design and mechanical details for attachment through membrane.

D. Manufacturer: Pate, Thybar, ThyCurb, Roof Products Systems, or equal.

2.04 ACCESS DOORS FOR WALL AND CEILING APPLICATIONS

A. Provide all access doors and panels to service equipment under this work, including those which must be installed, in finished architectural surfaces. Refer to other specification sections for specific access doors associated with ductwork and equipment.

B. Construction:

1. Frame: 16-gauge steel (minimum).
2. Door: 16-gauge steel (minimum) or two layers of 20-gauge steel (minimum) for double wall door construction.
3. Hinge: 1" flange width, continuous piano hinge.
4. Latching System: screwdriver latch, allen key latch or T-handle latch for non-public access areas. Cylinder key lock for public access areas. Cam latch for access to fire/life safety systems.
5. Paint: Exterior pre-finished to match Metal Soffit Panel color.

C. Size:

1. Access doors shall be of a size to permit access and removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer, concealed valve, fire and combination fire/smoke dampers, volume dampers, and other equipment requiring access. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through.

D. Architectural Coordination:

1. Refer to Division 01 Architectural specifications and drawings for additional requirements for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans.
2. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to service equipment under this work and in the proper sequence to coordinate with construction schedule and with prior approval of the Owner’s Representative.
3. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.
4. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

E. Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, Durodyne, Austin Hardware, or equal.

2.05 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 23 Sections. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.

1. Labels shall be printed to match the abbreviations or spelled out names used in the construction drawings. Custom printed labels are acceptable for specialty services and equipment.

B. Plastic Duct Markers:

1. Provide duct labels to indicate the system and direction of flow. Submit a labeling product that is suitable for the surface to be labeled.
   a. Pressure sensitive, 16" long by 2-1/4" high (minimum), 3 mil thick high gloss adhesive backed vinyl, 1-1/2" high letters, and color coded per ducted service.

2. Nomenclature shall include service type and directional arrow as follows:
   a. Supply air (cold service): green background with white lettering.
   b. Supply air (hot service): yellow background with black lettering.
   c. Return air: blue background with white lettering.
   d. Relief air: blue background with white lettering.
   e. Outside air: blue background with white lettering.
   f. Exhaust air: blue background with white lettering.
   g. Other air services: Comply with ANSI and ASME A13.1standards.
   h. Direction of air flow.

C. Access Panel Markers: Provide 1/16" thick (minimum) engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve or device.

D. Plastic Equipment Signs:

1. Provide 4-1/2" x 6" (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2" high.
2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Tag number
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.

4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2"x11" bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

E. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Kolbi, or Brimar.

2.06 ACOUSTICAL BLANKET INSULATION

A. Application:

1. Wrap high noise producing equipment and ductwork where occupied room noise levels cannot be obtained by architectural room barrier construction alone.
   a. Wrap each variable air volume terminal where located above noise sensitive rooms such as conference rooms, lobbies and offices.
   b. Wrap ductwork where located above noise sensitive rooms such as conference rooms, lobbies and offices.

c. Wrap fans where located above noise sensitive rooms such as conference rooms, lobbies and offices.
d. Wrap chillers and pumps where located adjacent to noise sensitive rooms.

B. Manufacturers: Kinetics Noise Control #KNM-100ALQ, or equal by BRD Noise and Vibration Control, GLT Products #Vinaflex with Absorber/Decoupler, or Singer Safety Company, Quilted Fiberglass Panels.

C. Composite material, quilted, with reinforced aluminized-face, mass loaded limp vinyl bonded to scrim-face, quilted fiberglass absorber/decoupler.

D. The barrier shall be constructed of a 0.12" (3 mm) minimum, thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a minimum weight of 1.0 lbs./ft^2 (4.9 kg/m^2) and shall have a minimum STC rating of 28 as measured in an independent accredited acoustical laboratory in accordance with ASTM E90 and/or E413.

E. The decoupling layer shall be a combination of 1.0" (25 mm), minimum, fiberglass batting, non-woven porous scrim-coated glass cloth, quilted together in a matrix of 4" (100 mm) diamond stitch pattern which encapsulates the glass fibers.

F. The composite material shall be fabricated to include a minimum 2" (50 mm) wide barrier overlap tab extending beyond the quilted fiberglass to facilitate a leak-tight seal around field joints.

G. The barrier shall have a Flame Spread Index of no more than 10 and a Smoke Development Index of no more than 40 when tested for Surface Burning Characteristic per ASTM E84.

2.07 ELECTRICAL

A. General:

1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.
2. Provide all motors for equipment specified herein. Provide motor starters, controllers, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
3. Set and align all motors and drives in equipment specified herein.
4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted "U" cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

B. Quality Assurance:

1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.

C. Motors:

1. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment Specifications.
2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Unless otherwise noted on plans, all motors 3/4 HP and larger shall be rated for 3-phase operation above 200 volts. Unless otherwise noted on plans, all motors up to 1/2 HP shall be rated for 120-volt, single phase operation.
4. Temperature Rating: Motor meets class B rise with class F insulation.
5. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
6. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
    a. Frames: NEMA Standard No. 48 or 56; use driven equipment manufacturer's standards to suit specific application.
    b. VFD driven motors to be provided as inverter ready and equipped with a shaft grounding device.
    c. Bearings:
        1) Ball or roller bearings with inner and outer shaft seals.
        2) Regreasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
        3) Designed to resist thrust loading where belt drives or other drives product lateral or axial thrust in motor.
        4) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
        5) Enclosure type for various applications:
            a) Open drip-proof (ODP) motors for indoor use in clean air environments.
            b) Totally enclosed fan cooled (TEFC) motors for outdoor use and indoor application in dirty environments and in mechanical rooms.
            c) Totally enclosed air over (TEAO) motors for motors in the airstream of cooling towers and fluid coolers.
            d) Explosion proof motors where motor is located in environments with hazardous or flammable quantities of vapors, gases, mists or dusts or where motor is located inside ductwork or cabinets with hazardous vapors, gases, mists or dusts that exceed 25 percent of the lower flammability limit.
            e) Guarded drip-proof motors where exposed to contact by employees or building occupants.
            f) Weather protected Type I for outdoor use, Type II where not housed.
            g) Electronically commutated motor (ECM) for indoor use in clean air environments.
    d. Overload Protection: Built-in thermal overload protection where external overload protection is not provided and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
    e. Noise Rating: "Quiet."
    f. Efficiency:
        1) Motors shall have a minimum efficiency per governing State or Federal codes, whichever is higher.
        2) And, motors shall meet the NEMA premium efficiency standard.
    g. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Starters and Electrical Devices:

1. Motor Starter Characteristics:
   a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs.
   b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

2. Manual switches shall have pilot lights and all required switch positions for multi-speed motors. Overload Protection: Melting alloy or bi-metallic type thermal overload relays, sized according to actual operating current (field measured).
3. Magnetic Starters:
   a. Heavy duty, oil resistant, hand-off-auto (HOA), or as indicated, and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   b. Trip-free thermal overload relays, each phase, sized according to actual operating current (field measured).
   c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23 Controls sections.
   d. Built-in primary and secondary fused control circuit transformer, supplied from load side of equipment disconnect.
   e. Externally operated manual reset.
   f. Under-voltage release or protection for all motors over 20 hp.

4. Motor Connections: Liquid tight, flexible conduit, except where plug-in electrical cords are specifically indicated.

E. Low Voltage Control Wiring:

1. General: 14-gauge, Type THHN, color coded, installed in conduit.
2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., or Southwire Co.

F. Disconnect Switches:

1. Fusible Switches: For equipment 1/2 HP or larger, provide fused, each phase; heavy duty; horsepower rated; spring loaded quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics as indicated.
2. Non-Fusible Switches: For equipment less than 1/2 horsepower, switch shall be horsepower rated; toggle switch type with thermal overload quantity of poles and voltage rating as required.

PART 3 - EXECUTION

3.01 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work unless so indicated on Drawings or as approved by Owner's Representative.

3.02 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

1. If the contractor must deviate from the manufacturer's recommendations provide a letter from the manufacturer indicating the clearance to be provided is acceptable for scheduled performance and maintenance.

3.03 INSTALLATION

A. Coordinate the work between the various Mechanical Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Engineer and at the Contractor's cost. Coordinate wall and ceiling work with the General Contractor, and other trades in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

B. Coordinate all condensate piping from cooling coils with Division 22 work. Provide equipment bases and curbs with enough height to provide a minimum of 8" clearance between bottom on equipment condensate outlet and adjoining surface to allow for adequate installation space for the water filled condensate traps. Water trap depth shall not be less than 3" and increased where system static pressure exceeds 2" external static plus 1" additional safety factor.

1. Install manufacturer provided condensate "air-traps" where provided with cooling equipment and condensing boilers. Install traps per manufacturer's instructions and install condensate piping as required by local code.

3.04 SUPPORTS AND HANGERS

A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with the General Contractor, installer of each component of associated work, inspection and testing agency representatives, (if any), installers of other work with requirements specified.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where Gypcrete is indicated, install reinforcing bars through opening at top of inserts. Inserts and anchors shall be located no closer than 6" to any edge and no closer than 1" from any pre-tension cables or embedded steel and as required per manufacturer's instructions and Structural Engineer.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, rails, and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

E. Support sprinkler piping and gas independently of other piping.

F. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

G. Installation of Anchors:

1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops and bends.

H. Drilled-in Anchors:

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

I. Equipment Supports:

1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction. Coordinate size of concrete pads and placement of

anchors bolts with structural design. Anchor bolts shall be placed to maintain 6", minimum, or greater distance from concrete pad edges.

2. Provide structural steel stands to support equipment above floor mounted or suspended from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

J. Adjusting:

1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

K. Upper Building Attachments: Powder-actuated fasteners may be used where appropriate for construction materials to which hangers are being attached per the following:

1. Maximum allowable tension load shall not exceed 50 lbs. (0.2 kN) per attachment.
2. May only by used to supporting for ductwork up to two (2) square feet (0.2 m^2) in cross sectional area and for control conduit clips.
3. May not be used for support of any ductwork greater than two (2) square feet (0.2 m^2) in cross sectional area.
4. Use concrete inserts before placing concrete in new construction.
5. Install powder-actuated concrete fasteners after concrete is placed and completely cured to concrete compressive strength of 4000 psi or greater.
6. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
7. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
8. Do not use powder-actuated concrete fasteners for seismic restraints.

3.05 WALL, FLOOR, AND ROOF PENETRATIONS

A. All duct penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Penetrations of fire-resistance-rated assemblies shall be protected by an approved firestop system installed and tested in accordance with ASTM E814 or UL 1479. The system shall have an F rating/T rating of not less than the required rating of the floor or wall penetrated. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below. Coordinate the required opening sizes with the manufacturer of the fire protection products.

3.06 ROOF CURBS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed, as applicable.

C. Verify roof insulation thickness and adjust the height of perimeter cant strips to accommodate insulation and roofing material installation.

D. Provide rigid insulation, minimum 1" thick, on exposed elements of roof curb.

E. Provide additional rigid insulation inside the roof curb perimeter secured to roof surface, around ductwork penetrations, to match the adjacent roof insulation levels (same R-value or greater).

3.07 EQUIPMENT RAILS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed, as applicable.

C. Verify roof insulation thickness and adjust the height of perimeter cant strips to accommodate insulation and roofing material installation.

3.08 ELECTRICAL COORDINATION

A. Division 23 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.

B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA's "Standard of Installation" to ensure that products fulfill requirements.

C. Division 23 has responsibilities for electrically powered mechanical equipment which is specified in Division 23 Specifications or scheduled on Division 23 Drawings as follows:

1. Motors: Furnish and install all motors necessary for mechanical equipment.
2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 23 equipment, also furnish and install the power wiring between starter and motor.
3. Variable Frequency Drives: Provide all VFD's associated with mechanical equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
4. Disconnects: Provide the disconnects which are part of factory wired Division 23 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.
5. Controls: Division 23 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
    a. Additional control panels beyond what is identified on drawings shall be provided by BAS contractor in order to provide a complete control system at no additional cost to Owner.
    b. Control relays necessary for controlling Division 23 equipment.
    c. Control transformers necessary for providing power to controls for Division 23 equipment.
    d. Line voltage thermostats.
    e. Low or non-load voltage control components.

f. Remote bulb thermostats.
g. Non-life safety related valve or damper actuators.
h. Float switches.
i. Solenoid valves.
j. Switches.
k. Refrigeration controls.
l. Communications wiring and conduit between control devices and mechanical equipment. Control wiring gauge in stranded or solid wire configuration shall be the responsibility of the contractor to coordinate with manufacturers for allowable lengths and load requirements to assure complete and operational systems.
m. Raceway to support control cabling.

6. Fire/Smoke Dampers: Division 23 is responsible for providing and physically installing the damper and for installing any required control interface wiring to Division 23 controls.
   a. Where fire/smoke dampers are part of an integrated smoke control system, Division 23 is responsible for providing dampers with necessary end switches for use by Division 28 in providing proof of closure.
   b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed in ductwork by Division 23 but wired to the damper controller by Division 26.

D. Division 26 Electrical Responsibilities:

1. BAS Controls Contractor shall initiate and coordinate a meeting with the Electrical Contractor and General Contractor to coordinate all BAS component locations and wiring requirements prior to start of construction. All additional costs associated with lack a coordinated shall be the responsibility of the BAS Contractor at no additional cost to the Owner.
2. Additional power requirements, including conduit and wiring, for additional or relocated control panels and devices shall be coordinated and the responsibility of the BAS Controls Contractor at no additional cost to Owner.
3. Motors: Provide the power wiring for the motors from servicing panel to motor controller.
4. Magnetic Starters: Except where magnetic starters are factory installed on Division 23 factory assembled equipment, Division 26 is to install magnetic starters furnished by Division 23 and install the necessary power wiring to the starter and from the starter to the motor. In the case of factory installed starters, Division 26 is to install the necessary power wiring from source panel/disconnect to the starter.
5. Variable Frequency Drives: Provide the necessary power wiring to the VFD and from the VFD to the motor except in the case of factory installed VFD's where wiring between the motor and VFD is to be by Division 23.
6. Disconnects: Provide all disconnects necessary for Division 23 mechanical equipment which are not provided as part of factory wired Division 23 equipment. Provide power wiring to all disconnects. In addition, provide power wiring between motor and disconnect when the disconnect is not factory installed.
7. Controls: Division 26 is responsible for providing power to mechanical control panels and provide final power connection to Division 23 provided control transformers.
8. Fire/Smoke Dampers: Division 26 is responsible for power wiring to each damper and as follows:
   a. Where these dampers are part of an integrated smoke control system Division 28 is responsible for providing the detectors and for all fire/smoke detection system wiring necessary to integrate dampers and related end switches into the system.

b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct smoke detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed by Division 23, but wired for damper control by Division 26.

E. Motors and Motor Control Equipment: Conform to the standards of the NEMA. Equip motors with magnetic or manual line starters with overload protection. Motor starters and line voltage controls shall be installed under Electrical Section but located and coordinated as required under this Section of the work. Starters shall be combination type with non-fusible disconnect switches. All single phase fractional horsepower motors shall have built-in overload protection.

3.09 FIELD PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Section 099100: Painting. Painting schemes shall comply with ANSI A13.1.

B. Paint all exposed materials such as piping, framing, supports, black steel, ductwork, equipment, insulation, galvanized steel, etc. The inside surface of visible ductwork above diffusers/grilles/registers shall be painted flat black.

C. All exposed work under Division 23 shall receive either a factory finish or a field prime coat finish, except:

1. Exposed copper piping.
2. Exposed stainless steel.
3. Exposed aluminum.
4. Aluminum jackets installed over outdoor insulation.

3.10 FACTORY PAINTING

A. Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120°F (50°C), the factory painting system must be designed for the temperature service.

3.11 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Ductwork Identification: A minimum of every 50' for all ductwork, 12" or more in diameter or width, where ducts are concealed above accessible ceilings.

C. Mechanical Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:

1. Main control and operating valves, including safety devices.
2. Meters, gauges, thermometers, and similar units.
3. Pumps.
4. Chillers.
5. Boilers.
6. Fans.
7. Compressors and similar motor-driven units.
8. Balancing dampers and mixing boxes.
9. Packaged HVAC central-station and zone-type units.
10. Strainers, filters, treatment systems and similar equipment.

D. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

3.12 VIBRATION AND DYNAMIC BALANCING

A. All equipment submitted and installed by Division 23 shall not exceed maximum tolerances as specified by the "International Research and Development Corporation", Worthington, Ohio, measured by the displacement, peak to peak, as follows:

1. All Fans: Below severity chart labeled "FAIR", maximum velocity of 0.0786 in/sec, peak.
2. Pump and Electric Motors: Below severity chart labeled "SLIGHTLY ROUGH", maximum vibration velocity of 0.157 in/sec, peak.
3. Compressors: Same as pumps.

B. Where installed equipment noise or vibration is objectionable to the Owner's Representative, it shall be responsibility of the contractor to conduct testing to confirm that the equipment does not exceed the standard.

C. Correction shall be made to all equipment, which exceeds vibration tolerances specified above. Final vibration levels shall be reported as described above.

3.13 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner's Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Ductwork: Test all air quantities as specified in Section 230593 - Testing, Adjusting and Balancing. Pressure tests per SMACNA.

C. Registers and Diffusers: Test for proper operation of manually operated control feature. Test all air quantities as specified in Section 230593 – Testing, Adjusting and Balancing.

D. Ductwork Specialties: Test all operable ductwork specialties for proper operation. Check all fire, smoke and fire/smoke dampers to ensure that they are 100% open.

E. Temperature Control: Test all control functions to assure that all systems are controlling as specified or as otherwise necessary and that all controls are adjusted to maintain proper room temperatures. The manufacturer's representative shall perform all tests.

END OF SECTION 230500

SECTION 230548 - VIBRATION ISOLATION FOR PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SUMMARY

A. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

B. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All mechanical equipment, piping and ductwork as noted on the equipment schedule, in the specification or as required by code shall be designed to resist seismic forces. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment

D. This Section includes the following:

1. Vibration isolation curbs, pads and mounts.
2. Flexible ductwork connectors
3. Spring hangers with and without vertical-limit stops.
4. Spring isolators.
5. Restrained uni-directional seismic isolation snubber mounts.
6. Housed seismic spring vibration mounts.
7. Elastomeric hangers.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Air-mounting system.
11. Restrained vibration isolation roof-curb rails.
12. Seismic snubbers.
13. Vibration isolation equipment bases.
14. Flexible piping connectors

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230549: Seismic Restraint for Piping, Ductwork and Equipment.

1.04 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. FRT: Fire retardant treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84 or UL 723, a listed flame spread index of 25 or less.

C. IBC: International Building Code with State Amendments.

D. ICC-ES: ICC-Evaluation Service.

1.05 CODES AND STANDARDS

A. Provide components conforming to the load requirements of the latest addition of the local building code and the following:

1. International Building Code with AHJ Amendments
2. American Society of Civil Engineers (ASCE):
   a. ASCE 7 (Latest Edition): Minimum Design Loads for Buildings and Other Structures.

3. The Manufacturers Standardization Society (MSS):
   a. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
   b. MSS SP-69: Pipe Hangers and Supports - Selection and Application.
   c. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices
   d. MSS SP-127: Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application.

4. Mason West Inc. Seismic Restraint Guidelines 2014 Edition
   a. For all suspended piping, suspended ductwork and suspended electrical raceways.

1.06 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment for seismic specific requirements.
2. Vibration isolators must be rated for the seismic loading associated with the system and forces calculated for this building location. Seismic forces for new installations are determined per ASCE 7. Refer to Structural Design for seismic factors and design criteria. Select and submit appropriate values for each piece of equipment and sub-system and material type for the project, and base the seismic calculations on these values.
3. Coordinate all seismic and load requirements with the registered professional Structural Engineer.

B. Component Importance Factor:

1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7 Section 13.1.3 regardless of Risk Category; or Hospitals and Correctional Treatment Centers. Components include, but are not limited to the following:
   a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
   b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.

1.07 QUALITY ASSURANCE

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

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

C. Building Structural Limits: The design of supports and restraints shall not exceed the building structure allowable point loads. Coordinate all work with the registered professional Structural Engineer.

D. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

1.08 WARRANTY

A. Provide minimum one-year warranty requirements, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

1.09 SUBMITTALS

A. Product Data shall include the following:

1. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
2. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.

3. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
4. 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 or agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
2. Provide all details of suspension and support for ceiling hung equipment.
3. Where walls, floors, slabs or supplementary steel work are used for seismic restraint the locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
4. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

C. Manufacturer Design Submittal: For vibration isolation 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 and where required wind forces required to select vibration isolators, seismic and wind 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. Provide base with level top surfaces with integral sloping on bottom to match support structure.

D. Coordination Drawings: Show coordination and plan locations of vibration isolation for HVAC ductwork, piping, and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Qualification Data: Devices shall be selected to meet seismic and support requirements by a registered professional Structural Engineer.

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent test agency.

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

1.10 WARRANTY

A. Refer to section 230500 for basic warranty requirements.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS AND APPLICATION

A. Factory Finishes:

1. Standard paint applied to factory-assembled equipment before shipping.
2. Powder coating on springs and housings.
3. All hardware shall be galvanized or powder coated.
4. Hot-dip galvanized or powder coating of metal components for exterior use.
5. Baked enamel or powder coat for metal components for interior use.

B. Glumac Device Key Schedule: Part 3 of this Section schedules the application of devices described in Part 2 for use with mechanical equipment found on this project. The tag designation of preferred devices is as follows:

Glumac Isolator Tag	Description
P-1	Vibration isolation waffle pad
P-2	Double deflection neoprene mount
P-3	Uni-directional restrained neoprene snubber mount
P-4	Interlocking uni-directional snubber
S-1	Open spring vibration isolator
S-2	Steel housed seismic spring vibration isolator
S-3	Bellows air spring isolator
S-4	Restrained air spring isolator
C-1	Seismic spring isolation roof curb (20 ton HVAC and below)
C-2	Seismic spring isolation roof curb (Greater than 20 ton HVAC)
C-3	Curb mounted spring isolation roof base
B-1	Integral equipment and motor base
B-2	Integral equipment and motor base
B-3	Concrete filled steel inertia base
H-1	Spring and rubber in shear vibration isolation hanger
G-1	All-directional pipe anchor
G-2	Vertical pipe guide
G-3	Horizontal thrust restraint
SB-1	Sway bracing
F-1	Kevlar/rubber spherical type flexible piping coupling
F-2	Stainless hose flexible piping coupling
F-3	Flexible expansion joints
F-4	Flexible ductwork connector

2.02 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:

1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Kinetics Noise Control.
5. Vibration Eliminator Co., Inc.
6. Vibration Isolation.
7. Vibration Mountings & Controls (VMC Group)
8. Vibro-Acoustics, Inc
9. Vibrex
10. VMC Group

B. P-1 Style: Neoprene pads shall consist of a 3/4" (19 mm) thick neoprene pad molded in square waffle modules, a minimum 1/4" (6 mm) thick steel load distribution plate and 3/4" (19 mm) hole with a neoprene anchor bolt bushing with a flat washer face. Pads may be single or multiple layers as required for leveling. Manufacturers: Mason #MBSW Series or equal.

C. P-2 Style: Restrained bridge bearing neoprene mountings shall have a minimum static deflection of 0.2" (5mm) and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Manufacturers: Mason #BR Series, VMC Group #YRSM3 Series, or equal.

D. P-3 Style: All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4" (6 mm) thick. A minimum air gap of 1/8" (3 mm) shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. No sharp edges such as bolt threads may come in contact with the neoprene bushing. Snubber end caps shall be removable to allow inspection of internal clearances. Manufacturers: Mason #Z-1225 Series or equal.

E. P-4 Style: All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of 3/4" (19 mm) thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" (3 mm) and not more than 1/4" (6 mm). Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8" (9 mm) deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to 1/2" (12 mm) deflection in the x, y and z planes. Manufacturers: Mason #Z-1011 Series or equal.

F. S-1 Style: Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" (6 mm) neoprene acoustical friction pad between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. 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. Two base plate holes for attachment to support surface. Manufacturers: Mason #SLFH Series or equal.

G. S-2 Style: Restrained spring mountings shall include springs that are free standing and laterally stable and complete with a molded neoprene cup or 1/4" (6 mm) neoprene acoustical friction pad between the spring and the mounting base plate. All spring assemblies shall have leveling bolts. 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. Mount housing shall include vertical limit stops to prevent spring extension when weight is removed. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal directions. A minimum clearance of 3/8" (9 m) shall be maintained around restraining bolts so as not to interfere with the spring action. Manufacturers: #SLR Series or #SLRS Series for steel/wood connections and Mason #SLREBP Series or #SLRSEBP Series or #SSLFH Series for concrete connections, or equal.

H. S-3 Style: Multiple bellow air springs shall be manufactured with powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz. Burst pressure must be a minimum of three (3) times the published maximum operating pressure. All air spring systems shall be equipped with three (3) leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8" (3 mm). An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician. Manufacturers: Mason #MT and leveling valves Mason #LV, or equal.

I. S-4 Style: Restrained mountings shall include multiple bellow air springs manufactured with powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz. Burst pressure must be a minimum of three (3) times the published maximum operating pressure. Mount housing shall include vertical limit stops to prevent spring extension when weight is removed. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal directions. A minimum clearance of 3/8" (9 mm) shall be maintained around restraining bolts so as not to interfere with the spring action. Mountings shall have test reports or calculations certifying the maximum allowable horizontal and vertical load ratings. All air spring systems shall be equipped with three (3) leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8" (3 mm). An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician. Manufacturers: Mason #SLR-MT for steel connections and Mason #SLREBP for concrete connections and leveling valves Mason #LV, or equal.

2.03 SEISMIC RESTRAINED SPRING VIBRATION ISOLATION ROOF-CURB (C-1) (HVAC UNITS 20 TON AND UNDER CAPACITY)

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:

1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.

5. Kinetics Noise Control.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls (VMC Group)
10. Vibro-Acoustics, Inc.
11. VMC Group

B. C-1 Style: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. Curbs shall consist of continuous sheet metal frames above and below isolators. Isolators shall be adjustable, free-standing and laterally stable and include a 1/4" (6 mm) acoustical neoprene cup and leveling bolt. Spring diameters shall be no less than 0.8 of the compressed height of the spring at the rated load with 50% additional travel to solid. Seismic snubbers with an all directional neoprene bushing and 1/4" (6 mm) air gap shall be incorporated into each corner. A continuous sheet metal flashing shall be attached to the upper frame and be separated from the lower frame by a neoprene weatherseal. The sheet metal flashing shall incorporate removable cover plates for adjustment and inspection of isolators after the unit is set. The unit must be solidly fastened to the top steel frame and the lower sheet metal curb must be attached to the roof structure. Manufacturers: Mason #ISC Series or equal.

C. C-3 Style: Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the rigid roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro-galvanized or powder coated springs selected for 0.75" (20 mm) minimum deflection. Travel to solid shall be 1.5" (40 mm) minimum. Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4" (6 mm) so as not to interfere with the spring action except in high winds. Manufacturer's self adhering closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM ductlike closure. Submittals shall include spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details. Manufacturers: Mason #CMAB Series or equal.

2.04 SEISMIC RESTRAINED SPRING VIBRATION ISOLATION ROOF-CURB (C-2) (HVAC UNITS OVER 20 TON CAPACITY)

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:

1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls (VMC Group)
10. Vibro-Acoustics, Inc.
11. VMC Group

B. C-2 Style: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4" (6 mm) thick. Steel springs shall be laterally stable and rest on 1/4" (6 mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" (50 mm) of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Manufacturers: Mason #RSC Series or equal.

2.05 VIBRATION ISOLATION STEEL EQUIPMENT BASES

A. Basis-of-Design Product: Subject to compliance with requirements provide a comparable product by one of the following:

1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.
8. Vibration Mountings & Controls (VMC Group)
9. Vibro-Acoustics, Inc.
10. VMC Group

B. B-1 Style: Vibration isolation manufacturer shall furnish integral structural steel bases designed to prevent excessive base flexure at start up, prevent misalignment of equipment and provide attachment points for seismic restraints. Bases shall be rectangular in shape and constructed of welded structural steel angle or channel members. Manufacturers: Mason #MSL Series or equal.

C. B-2 Style: Vibration isolation manufacturer shall furnish integral structural steel bases designed to prevent excessive base flexure at start up, prevent misalignment of equipment and provide attachment points for seismic restraints. Bases shall be rectangular in shape and constructed of welded wide flange structural steel main members with cross bracing located at or near each restraint location. Where height saving brackets are required, they shall be employed in all mounting locations to maintain a 1" (25 mm) clearance below the base. Manufacturers: Mason #WFSL Series or #TSLR Series, or equal.

D. B-3 Style: Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows and shall be 6” deep for pumps through 75 hp and 10” deep for pumps 100 hp through 250 hp. Forms shall include minimum concrete reinforcing consisting of #4 bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all

mounting locations to maintain a 1" clearance below the base. Manufacturers: Mason #BMK Series or #KSL Series or equal.

2.06 SPRING HANGERS

A. H-1 Style: Spring hangers shall consist of rigid steel frames containing minimum 1-1/4" (32 mm) thick neoprene elements at the top and steel springs that are free standing and laterally stable seated in a steel washer reinforced neoprene cup at the bottom. 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. The neoprene element and the cup shall have a neoprene bushing projecting through the steel box. A seismic rebound washer made of steel and surrounding neoprene shall be provided. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Manufacturers: Mason #RW30N Series or equal.

2.07 PIPE GUIDES AND SUPPORTS

A. G-1 Style: All-directional acoustical pipe anchors shall consist of two sizes of steel tubing separated by a minimum 1/2" (12 mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. Manufacturers: Mason #ADA Series or equal.

B. G-2 Style: Vertical sliding pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" (20 mm) thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of 1-5/8" (41 mm) upwards or downwards motion, or to meet location requirements. Manufacturers: Mason #VSG Series or equal.

C. G-3 Style: Horizontal thrust restraints shall consist of a spring element seated in a steel washer reinforced neoprene cup at the bottom, in series with a molded neoprene element. Steel springs shall be free standing and laterally stable. 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. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" (6 mm) movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Manufacturers: Mason #WBI Series or #WBD Series or equal.

2.08 SWAY BRACING

A. SB-1 Style: Seismic sway braces shall consist of galvanized steel aircraft cables or steel angles or struts. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads with a minimum safety factor of two (2). Brace end connections shall be steel assemblies that swivel to the final installation angle. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps. Do not mix cable

and steel braces to brace the same system or equipment. Manufacturers: Mason #SCB Series or #SCBH Series, steel brace assemblies shall be Mason #SSB Series, #SSBS Series or #SHB Series, and rod clamps shall be Mason #SRC Series or #UCC Series or equal.

2.09 FLEXIBLE PIPING CONNECTORS

A. F-1 Style: Flexible spherical expansion joints for pump connections. Shall employ peroxide cured EPDM in the covers, liners and Kevlar tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16" to 24" may be single sphere. Sizes 3/4" to 1 1/2" may have threaded bolted flange assemblies, one sphere and cable retention. 14" and smaller connectors shall be rated at 250 psi up to 190F with a uniform drop in allowable pressure to 190 psi at 250F. 16" and larger connectors are rated 180 psi at 190F and 135 psi at 250F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5-minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Manufacturer shall provide pre-stretching charts for expansion joints when used in conjunction with isolated equipment. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2" thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Manufacturers: Mason #SAFEFLEX SFDEJ Series, #SAFEFLEX SFEJ Series, #SAFEFLEX SFDCR Series or #SAFEFLEX SFU Series and Control Rods Mason #CR, or equal.

B. F-2 Style: Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings.

1. Sizes 1/2" (15 mm) to 2” (50 mm):
    a. EPDM or Kevlar core hose with stainless steel braid and brass end fittings. Swivel union ends for threaded nipples or copper sweat ends. Minimum 175 psig working pressure rating. Operating temperature range from 32°F to 225°F (0°C to 107°C). Hoses must have sufficient length, minimum 12” (300 mm) long, to accept 1/2” (12 mm) intermittent motion without failure. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Manufacturers: IMI #Versaflow, Nexus #UF Series, Pro Hydronic Specialties, Titus, Victaulic, Hays Fluid Control, or equal.

2. Sizes 2-1/2” (65 mm) and larger:
    a. EPDM, Kevlar or corrugated stainless-steel core hose with stainless-steel braid. Threaded, flanged or brazed weld ends. Minimum 200 psig working pressure rating. Operating temperature range from 32°F to 225°F (0°C to 107°C). Manufacturers: Mason #FFL Flanged, #CPSB Copper, #CSAMN Threaded, or equal.

C. F-3 Style: Flexible 60° Vee or U-bend braided hose across building or expansion joints. Piping and equipment connections shall be protected against seismic damage by the insertion of braided flexible hose Vee assemblies rated for ±4" (100mm) seismic motion in all planes. Should the application include ±6" (150mm) thermal movement or thermal movement alone, install the Vee so the thermal movement is axial. Vees shall have a minimum burst pressure of four times their rated pressure. Vees in steel lines shall have stainless hose and braid. Copper lines, bronze hose and braid. Guiding and anchoring shall be as recommended by the manufacturer. Manufacturers: Mason #VFL flanged braided steel Series, #VMN Threaded Braided Stainless Steel Series or #VCPSB Copper Sweat Series, or equal.

2.10 FLEXIBLE DUCTWORK CONNECTORS

A. F-4 Style: Flexible ductwork connection fabricated of fiberglass canvas with fire resistant rated neoprene and UV resistant coating. Stainless steel metal edge banding.

B. Flexible Connections (Indoor Applications):

1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
6. Surface-Burning Characteristics: Maximum flame-spread index of 20 and maximum smoke-developed index of 40 when tested according to UL 723/ASTM E84.
7. Neoprene-only connectors are not allowed.
8. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal.
9. Manufacturers: Ventfabrics #Ventglas or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

C. Flexible Connections (Outdoor Applications):

1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Hypalon (chlorosulfurated polyethylene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant. Resistant to sunlight, ozone and weather.
4. Minimum density of 26 oz. per sq. yard.
5. Temperature range: -50°F to 275°F
6. Surface-Burning Characteristics: Non-combustible as tested per UL 701. Or, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.
7. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal.
8. Provide flexible cloth insulating blanket to encase flexible connections to maintain ductwork insulation integrity as follows:
    a. Jacket shall be UV and ozone resistant with Velcro attachment.
    b. Service Operating Temperature: 0-350°F.
    c. Jacket and Liner: silicon or teflon impregnated fiberglass or mineral wool cloth.
    d. Insulation: Aerogel, 2" thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
    e. Fastening: 2" Nomex Velcro or 1" straps and stainless steel D-rings.

f. Thread: Kevlar/stainless steel thread.
g. Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, or equal.

9. Manufacturers: Ventfabrics #Ventlon or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

2.11 BRACING DEVICES FOR EQUIPMENT, PIPING, AND DUCTWORK

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

1. Amber/Booth Company (VMC Group)
2. California Dynamics Corporation
3. Cooper B-Line, Inc.
4. Hilti, Inc.
5. Kinetics Noise Control
6. Loos & Co.
7. Mason Industries
8. Tolco Incorporated
9. Unistrut
10. ISAT, Inc
11. Vibro-Acoustics, Inc.
12. VMC Group

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least two (2) 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 (6-mm) air gap, and minimum 1/4” (6 mm) 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. Hanger Rod Stiffener: Steel tube, steel slotted support system sleeve or reinforcing steel angle clamped to hanger rod are acceptable.

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

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

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

I. 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 E488. Minimum length of eight times diameter.

J. 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 E488.

PART 3 - EXECUTION

3.01 LOCATION AND APPLICATION OF VIBRATION ISOLATION EQUIPMENT

A. The following Tables provide schedules for minimum vibration devices required for isolation of mechanical equipment provided on the project. Refer to Part 2 above for device specifications. Coordinate with additional requirements recommended by device manufacturers. Sizes show below take precedent as the minimum requirements. Use the greater of the sizes shown as follows or shown on the drawings.

B. Air Handling Units Equipment Isolation:

TABLE 1: EQUIPMENT ISOLATION SCHEDULE – AIR HANDLING UNITS

EQUIPMENT TYPE	EQUIPMENT LOCATION								
	ROOF AND FLOORS ON GREATER THAN 30' FLOOR SPAN (5)			UPPER FLOOR UP TO 30' FLOOR SPAN (5)			ON GRADE		
	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE
FLOOR MOUNTED									
Up to 15 HP	S-1 (1)	1	B-1 (1)/B-3	N/A	N/A	N/A	N/A	N/A	N/A
20 HP & Over	S-1 (1)	1	B-1 (1)/B-3	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
(1) Alternate: Factory installed by equipment manufacturer factory installed.
(2) Provide full perimeter steel welded frame below equipment
(3) Provide support per manufacturer's recommendation
(4) For pipe and duct connections provide F-2 pipe and F-4 duct connectors.
(5) Span is the beam or girder distance between columns or exterior fixed wall supports.

C. Miscellaneous Equipment Isolation

TABLE 2: EQUIPMENT ISOLATION SCHEDULE – MISCELLANEOUS EQUIPMENT

EQUIPMENT TYPE	EQUIPMENT LOCATION								
	ROOF AND FLOORS ON GREATER THAN 30′ FLOOR SPAN (5)			UPPER FLOOR UP TO 30′ FLOOR SPAN (5)			ON GRADE		
	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE
ROOFTOP AIR CONDITIONING UNITS									
Up to 20 Ton	S-2	1.5	C-1/C-3	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
(1) Alternate: Factory installed by equipment manufacturer.
(2) Provide full perimeter steel welded frame below equipment.
(3) Provide support per manufacturer's recommendation.
(4) For pipe and duct connections to units provide F-2 pipe and F-4 duct connectors.
(5) Span is the beam or girder distance between columns or exterior fixed wall supports.

3.02 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-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.

3.03 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service or agency acceptable to authorities having jurisdiction. Indicate on Drawings, by details, schedules, or a combination of both, the locations where hanger rods for individual pipes and hanger rods for trapeze hangers require hanger rod stiffeners.

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.

3.04 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

C. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

D. All vibration isolator systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

E. Installation of vibration isolators must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

G. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner’s Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

H. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

I. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

J. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

K. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

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

M. 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.

N. 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.

O. 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.

3.05 VIBRATION ISOLATION OF PIPING

A. Horizontal Piping: The first three pipe supports from vibration isolated equipment, including but not limited to pumps and chillers, must be vibration isolated to minimize fluid transmitted vibration into the building structure. The static deflection of the pipe support isolators must be equal to the static deflection for the isolators supporting the connected equipment. Overhead piping shall suspend from Mason Type 30N spring hangers or better. Floor supported piping shall rest on Mason Type SLR isolators or better. Refer to contract drawings for additional vibration isolation requirements for piping. Where piping connects to mechanical equipment install Mason Type SFDEJ or SFU expansion joints or Mason Type FFL stainless hoses if Type SFDEJ or SFU is not suitable for the service.

B. Riser isolation: Risers that experience excessive thermal expansion shall be suspended from Mason Type 30N spring hangers or supported by Mason Type SLF(H) spring mountings, anchored with Mason Type ADA(H) anchors, and guided with Mason Type VSG(H) sliding guides. Horizontal pipe runs and branches shall be supported on Mason Type 30N spring hangers for the first three supports from the risers. Steel springs shall be selected to provide a minimum of 0.75"static deflection except in those expansion locations where additional deflection is required to limit load changes to + 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

3.06 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.

3.07 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 air-spring leveling mechanism.

D. Adjust active height of spring isolators.

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

3.08 AIR MOUNTING SYSTEM DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 230548

SECTION 230549 – SEISMIC RESTRAINT FOR PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SUMMARY

A. This Section includes the following:

1. Seismic restraint and support of piping, ductwork and mechanical equipment as required by code and as designed by a registered Professional Structural Engineer for each related nonstructural equipment restraint.
2. Mechanical component supports and the means how they are attached to the mechanical component shall be designed for the forces and displacements determined in ASCE 7 Chapter 13. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.
3. All ductwork designed to carry toxic, highly toxic, flammable gases or used for smoke control shall be seismically braced regardless of size or location.

1.03 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. ASCE: American Society of Civil Engineers.

C. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

D. IBC: International Building Code with Amendments.

E. ICC-ES: ICC-Evaluation Service.

F. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

G. Mechanical Attachments: Means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

H. Mechanical Supports: Those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

I. Mechanical Components: Elements, including, but not limited to, pumps, air handling units, boilers, chillers, pipes, ductwork, and exhaust fans.

1.04 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230548: Vibration Isolation for Piping, Ductwork and Equipment.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Other Division 23 Sections.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Structural Performance: Restraint devices and systems shall withstand the effects of locally defined gravity loads, seismic loads, dead loads, live loads, winds loads and stresses within limits and under conditions indicated per the local building code and ASCE 7. Coordinate all support structures and restraint systems with project registered professional Structural Engineer.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

D. Codes and Standards: Provide components conforming to the seismic load requirements of the latest addition of the local building code and the following where applicable:

1. International Building Code with State Amendments

2. ASCE 7 (Latest Edition) - Minimum Design Loads for Buildings and Other Structures
   a. Ductwork and piping requirements defined in Chapter 13 Seismic Design Requirements for nonstructural Components.
   b. Seismic Design Categories, B through F, are defined in Chapter 12, Table 12.6-1. Seismic Design Category B and C apply to all structures. While Seismic Design Categories D, E and F may apply to Category I and II buildings not exceeding two stories, light frame construction and/or structures not exceeding 160 in height.
   c. Nonstructural components in Seismic Design Category A are exempt from seismic design requirements.

3. SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition.
   a. Seismic guidelines for ductwork and piping bracing as adopted by Authority Having Jurisdiction.

4. ASHRAE – Practical Guide to Seismic Restraint (Latest Edition).
5. ANSI/FM 1950: American National Standard for Seismic Sway Braces for Pipe, Tubing and Conduit (Latest Edition).
6. Factory Mutual (FM): Earthquakes Data Sheet 1-2 (Latest Edition).
7. Factory Mutual (FM): Earthquake Protection for Water-Based Fire Protection Systems Data Sheet 2-8 (Latest Edition).
8. Mason Industries/Mason West - Seismic Restraint Guidelines for Suspended Distribution Systems (Latest Edition).
   a. For all suspended piping, suspended ductwork and suspended electrical raceways.

1.06 APPLICABILITY

A. Seismic restraints are required for nonstructural mechanical systems, but may not be required for the following conditions related to nonstructural components per ASCE 7 Section 13.1.4:

1. Mechanical components in Seismic Design Category B facilities.
2. Mechanical components in Seismic Design Category C facility if the component Importance Factor, I_p, is equal to 1.0.
3. Mechanical components in Seismic Design Categories D, E, or F facilities where all of the following apply:
   a. The component Importance Factor, I_p, is equal to 1.0;
   b. The component is positively attached to the structure;
   c. Flexible connections are provided between the component and associated ductwork, piping, and conduit; and any of the following applies:
      1) The component weighs 400 lbs. (1,780 N) or less and has a center of mass located four feet (1.22 m) or less above the adjacent floor level; or
      2) The component weighs 20 lbs. (89 N) or less; or
      3) The distributed ductwork or piping system weights 5 lbs./ft. (73 N/m) or less.

B. Provide seismic bracing at the following locations per SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems (Latest Edition) and ASCE 7:

1. Piping:
   a. Transverse bracing shall be provided at 40 feet (12.2 m) maximum except where a lesser spacing is indicated in SMACNA tables.
   b. Longitudinal bracing shall be provided at 80 feet (24.4 m) maximum except where a lesser spacing is indicated in SMACNA tables. Anchor locations for thermal expansion may be used as longitudinal braces. Longitudinal braces must be capable of resisting the additional force induced by expansion and contraction.
   c. Bracing locations for insulated piping shall use welded lugs that extend through the insulation to allow improved continuity of insulation and vapor barriers. Bracing shall occur at locations other than normal support locations where clevis or trapeze type hangers are used.

2. Ductwork:
   a. Transverse bracing shall be provided at 30 feet (9.2 m) maximum except where a lesser spacing is indicated in SMACNA tables.

b. Longitudinal bracing shall be provided at 60 feet (18.4 m) maximum except where a lesser spacing is indicated in SMACNA tables.

3. Equipment:
   a. All suspended mechanical components weighing more than 20 lbs. (89 N) shall be seismically braced as required per ASCE 7 Section 13.1.4. However, equipment installed in-line with the duct system, with a weight up to 75 lbs. (334 N), such as fans, heat exchangers and humidifiers, may be considered as supported and laterally braced by the duct system as required per ASCE 7 Section 13.6.7.

C. Seismic restraints may be omitted where the following conditions apply and as allowed by the local Authority Having Jurisdiction (AHJ):

1. Ductwork supported by hangers and each hanger in the duct run is 12" (305 mm) or less in length from the duct support point to the supporting structure.
2. Ductwork cross-sectional area is less than six (6) square feet (0.557 m^2), round ductwork is 32 inches (0.8 m) in diameter, or less, or weighs 17 lbs./ft. (248 N/m) or less.
3. Pipes suspended by hangers 12" (305 mm) or less in length from the top of the pipe to the bottom of the supporting structure for the hanger. Where pipes are supported by trapeze, the trapeze shall be supported by hangers having a length of 12” (305 mm) or less.
4. Pipe bracing is not required where the following conditions apply:
   a. For Seismic Design Category C where the Ip value is greater than 1.0 and pipe sizes are 2” (50 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).
   b. For Seismic Design Category D, E, or F where the Ip is greater than 1.0 and pipe sizes are 1” (25 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).
   c. For Seismic Design Category D, E, or F and where the Ip equals 1.0 and pipe sizes are 3” (80 mm) in diameter or less, and piping weighs less than 10 lbs./ft. (146 N/m).

D. Seismically restrained piping systems shall not move more than 2” during a seismic event and shall not impact the building structure or other nonstructural components during a seismic event. The design force of restraint elements shall be doubled (2 x Fp) to allow for movement up to 2” per ASCE 7 Section 15.7.4.

1.07 PERFORMANCE REQUIREMENTS

A. Component Importance Factor and Risk Category:

1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7 Section 13.1.3 regardless of Risk Category, or Hospitals and Correctional Treatment Centers. Components include, but are not limited to, the following:
   a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
   b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold

quantity established by the AHJ and is sufficient to pose a threat to the public if released.

3. Additions, alterations, and repairs involving nonstructural mechanical components in structures designed in accordance with pre-1973 building codes may have a Component Importance Factor of Ip=1.0. However, components required to operate for life-safety purposes after an earthquake, including emergency and standby power systems, mechanical smoke removal system, fire alarm panels and egress stairways shall have an Ip=1.5.

B. Building Seismic Design Category:

1. The directions of application of seismic forces used in the design shall be those which will produce the most critical load effects. Seismic Design Categories are classified as B, C, D, E or F. Refer to Architectural and Structural Designs for project specific classification.

C. Mechanical Seismic Coefficients for Mechanical Components:

1. Refer to ASCE 7 Table 13.6-1 for a_p factor (component amplification factor) and R_p factor (component response modification factor) as required for each unique mechanical component.

1.08 SUBMITTALS

A. Product Data:

1. Include rated load, rated deflection, and overload capacity for each device or system.
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 or agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Submit seismic brace product details from the Mason West Seismic Restraint Guidelines detailing compliance with the specifications.
4. Where products from the Mason West Seismic Restraint Guidelines cannot be used, special details must be submitted for approval.

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

1. Seismic restraint calculations must be provided for all connections to the structure.
2. Calculations must be stamped by a registered professional Structural or Civil Engineer.
3. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. 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 was examined for excessive stress and that none exists.

5. Provide flexible joints, supports and piping joints as required to accommodate movement across seismic expansion joints and vertical building drift between floors.

1.09 ENGINEERED PIPING SYSTEMS

A. Where the piping system design indicated on the plans utilizes Mason Industries, Inc. - Mason West, Inc. seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors the following requirements apply:

1. Mason Industries, Inc. - Mason West, Inc. products must be installed as shown.
2. If product substitutions or design changes are made the contractor must provide certified design of the piping system and meet the following conditions:
    a. Certification must be provided by a registered professional Structural Engineer.
    b. Certification shall include a statement that all systems have been checked for loads and stresses and that no excessive loads or stresses exist.
    c. Forces on all anchors, guides, supports, and restraints must not exceed those shown in the original design unless the structure is checked for the larger loads at no cost to the owner.

B. Where the piping system design is not indicated on the drawings the design is delegated to the contractor with the following requirements for piping certification and analysis:

1. The supports, anchors, guides and seismic braces for systems with significant thermal motion including steam, condensate, high temperature hot water and heating hot water systems must be designed for combined gravity, seismic, pressure and thermal loads.
2. Small diameter pipes (2" diameter and smaller) may not require analysis as determined by the project registered professional Structural Engineer.
3. The results of the analysis shall include reactions at restraints and anchors, maximum pipe displacements and a code compliant report indicating maximum pipe stresses.
4. Where required, seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors manufactured by Mason Industries, Inc. and Mason West, Inc. shall be incorporated into the design of the systems.
5. The analysis and design must be performed by a Structural Engineer with 5 years of experience in this field.

1.10 MANUFACTURER AND CONTRACTOR RESPONSIBILITIES

A. All seismic restraints shall be designed by a registered professional Structural Engineer.

B. Seismic restraint layouts for piping and ductwork shall be added to the contractor's shop drawings and shall include:

1. The number, size and location of seismic braces.
2. Maximum support loads and seismic loads at the seismic brace locations.
3. Reference to specific details or pages from the Mason West Seismic Restraint Guidelines.

C. Submit seismic restraint layout drawings and special details for approval of the project registered professional Structural Engineer per the requirements listed in the Mason West Seismic Restraint Guidelines.

D. Seismic restraint layout drawings shall bear the stamp and signature of the registered professional Structural Engineer who designed the layout of the braces.

1.11 LOADS ON STRUCTURE

A. The responsibility of determining allowable loads on the structure is the sole responsibility of the project registered professional Structural Engineer.

B. Maximum support loads and seismic brace loads on the structure must be less than the maximum allowable loads defined by the project registered professional Structural Engineer, as shown on the plans.

C. Where maximum loads are not listed on the plans or the maximum allowable loads cannot be met, any additional support steel required to reduce support and seismic bracing loads on the structure shall be designed by the project registered professional Structural Engineer.

D. Mechanical component supports and the means how they are attached to the component shall be designed for the forces and displacements determined in ASCI 7 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

E. Mechanical supports are those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical attachments are the means how components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

1.12 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 INTENT

A. All seismic restraints described in this section shall be the product of a single manufacturer.

B. Refer to Section 230500 for additional guidelines for applicable supports and anchors.

C. Mason Industries products are the basis of these specifications; products of other manufacturers may be submitted for review provided their systems strictly comply with the specifications. Manufacturers: Mason Industries, Hilti Inc., B-Line/Tolco (Eaton), Anvil, Superstrut, or equal.

2.02 SEISMIC SWAY BRACING

A. Seismic sway braces shall consist of galvanized steel aircraft cables, steel angles or steel struts.

B. Cable braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads. Brace end connections shall be steel assemblies that swivel to the final installation angle.

C. Cable brace assemblies shall have published strength and stiffness ratings based on testing per the ANSI/FM-1950 standard.

D. Angle or strut bracket assemblies shall be FM Approved except as noted below.

E. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps.

F. Cable and universal swivel sway brace bracket attachment assemblies shall be Mason Industries #SCB or #SCBH, or equal.

G. Solid and swivel brace bracket assemblies shall be Mason Industries #Type SSB or #SSBS, or equal.

H. Rod clamps shall be Mason Industries #SRC or #UCC, or equal.

I. Welded pipe hanger lug shall be Mason Industries #MW-WPL, or equal.

J. Pipe clamp with integral hanger lug shall be Mason Industries #MW-SPC, or equal.

K. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork and suspended diffusers/grilles/terminal units.

1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

PART 3 - EXECUTION

A. Contractor's Statement of Responsibility: Each contractor responsible for installing a Designated Seismic System or any seismic resisting component must submit a statement of responsibility prior to the commencement of work to include acknowledgment of awareness of the need for Special Inspections.

B. All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

C. Installation of seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

D. No connections between the piping or ductwork and the building structure shall be made that degrades the seismic restraint system herein specified.

E. Any conflicts with other trades due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner's Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

END OF SECTION 230549

SECTION 230593 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 WORK RELATED IN OTHER SECTIONS

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230900: Building Automation System (BAS) Controls.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Division 26: Electrical.

1.03 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section is indicated on the drawings, in schedules, and by the requirements of this Section, and Section 230500 -Basic Mechanical Requirements.

B. Systems: Testing, adjusting and balancing specified in this Section shall include, but not be limited to, the following systems:

1. Air handling systems including supply, return and exhaust.
2. Air distribution ductwork including supply, return and exhaust.
3. Dedicated exhaust systems.
4. Building automation system controls.
5. Hydronic system including heating water
6. Instruction of Owner's personnel for future balancing of systems.

1.04 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Reference Standards

1. ANSI/ASHRAE Standard 111 - Measurement, Testing, Adjusting and Balancing of Building HVAC Systems (current edition).
2. ASHRAE - HVAC Applications Handbook: Chapter 38 - Testing, Adjusting and Balancing (current edition).
3. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings, Chapter 6 (current edition).
4. AABC - National Standards for Total System Balance.
5. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
6. SMACNA - HVAC Systems-Testing, Adjusting and Balancing.
7. SMACNA - HVAC Air Duct Leakage Test Manual.
8. ANSI - American National Standards Institute. Comply with the following:
   a. S1.4: Specifications for Sound Level Meters.
   b. S1.11: Specifications for Electroacoustics - Octave-Band and Fractional-Octave-Band Filters
9. Building Code, with State Amendments, Chapter 9 Fire Protection Systems.
10. Mechanical Code, with State Amendments, Chapter 4 Ventilation Air Supply.
11. Local Nonresidential Energy Code.

1.05 QUALITY ASSURANCE

A. Contractor's Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 5 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, is not the installer of the system to be tested and is otherwise independent of the project. Testing, adjusting, and balancing shall be performed by a certified NEBB technician or a certified AABC technician under direct field supervision of a Certified NEBB Supervisor or a Certified AABC Supervisor. Testing and balancing agency must submit qualifications for review and approval prior to acceptance for work.

B. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 30 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

C. Retainages: In addition to any other sums retained or withheld pursuant to the provisions of this Contract, the amount of dollars will be withheld from payments to the contractor until such time as the work has been completed and accepted. In no event will this amount be paid to the Contractor prior to 60 days following acceptance of the project; during such time, the Contractor shall investigate and correct any reported deficiencies unless such deficiencies are a result of unauthorized tampering by building occupants.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 6 months.

E. Testing and balancing agency, as part of its contract, shall act as authorized inspection agency responsible to Consulting Engineer and Owner, and shall list all items that are installed incorrectly, require correction, or have not been installed in accordance with contract Drawings

and Specifications, pertaining to air distribution, cooling and heating systems. The testing and balancing agency is required to provide written reports of all deficiencies and proposed recommendations to the Owner' Representative, Contractor, Architect and Engineer.

F. The testing and balancing agency shall provide with their bid a performance guarantee covering all phases of the work as herein specified.

G. The General and Mechanical Contractors shall cooperate with the selected testing and balancing agency in the following manner:

1. Agency shall be third party, not Mechanical Contractor
2. Provide sufficient time before final completion dates so that tests and balancing can be accomplished.
3. The various system installers, suppliers and contractors shall provide all required materials, labor and tools to make corrections when required without undue delay. Install balancing dampers and valves as required by testing and balancing agency.
4. The contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of the same during each working day of testing and balancing.
5. Testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with a complete set of Record Drawings.
6. The General Contractor shall make space and other facilities available to the testing and balancing agency to enable their work to progress. The General Contractor shall schedule the work of other trades to avoid conflicts with this work.

H. All air balancing work shall be coordinated with other disciplines to comply with the meet or exceed the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, local amendments and State Energy Code.

1.06 SUBMITTALS

A. Conform to the Submittals requirements of Division 01.

B. Forms: The Contractor shall deliver a complete copy of either NEBB or AABC standard forms for testing and balancing work associated with the project. These forms shall serve as specific guidelines for producing final test report. Hybrid or non-standards forms are not acceptable.

C. Test Reports: Provide six (6) certified test reports, signed by the test and balance supervisor who performed the work. The final reports shall include key plans identifying all inlets and outlets. Final test reports shall be typed. Handwritten reports are not acceptable.

D. Maintenance Data: Include, in maintenance manuals, copies of certified and approved test and balance reports and identification of instruments.

E. Qualifications: The Test and Balance Agency shall submit qualifications of all persons responsible for supervising and performing the on-site testing and balancing work and the name of the certifying agency, NEBB or AABC. Provide a reference list of five (5) similar size projects with contact person and telephone number.

1.07 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.

1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating and cooling.
3. The agenda shall include a list of all air and water flows to be performed at all mechanical equipment.
4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas such as conference rooms.
5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall be submitted.
6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
    a. Air terminal configuration.
    b. Flow direction (supply or exhaust).
    c. Velocity corrections.
    d. Effective area applicable to each size and type of air terminal.
    e. Density corrections.

7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.08 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.

1. Installation and start-up work on equipment or systems to be tested has been completed and documented.
2. Work area scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested shall be in their completed normal positions and operation.
4. All related mechanical systems which may affect the operation of the system to be tested shall be at their normal operating conditions.

PART 2 - PRODUCTS

2.01 TEST HOLES

A. Test holes and ports shall be provided in ducts, housings and pipes as directed by the Balancing Agency. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.

2.02 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.

1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
2. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.03 TEST INSTRUMENTS

A. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner's Representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

B. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against Certified Calibrated instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

C. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser/grille/register air flow measurements. The readout meters shall meet calibration requirements.

PART 3 - EXECUTION

3.01 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by approved project drawings and specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four-hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.

1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
2. All labor, instruments, and appliances required shall be furnished by the Contractor. Permanently installed instruments used for the tests (e.g., flow meters and Btu meters) shall not be installed until the entire system has been cleaned and ready for operation.

3.02 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and located as required by these specifications and drawings and as required by the building codes and the following:

1. Obtain information from the Contractor who is to furnish the smoke detectors on the proper device placement and installation limitations and on the proper differential pressure across the sampling tubes of the duct detectors and for required air velocity range requirements.
2. Installing Contractor shall review the manufacturer's installation guidelines for proper mounting locations.
3. The testing and balancing agency shall be engaged to confirm that proposed mounting locations will not be adversely impacted by airflows.

B. Duct smoke detectors shall be tested in collaboration with the installing Contractor and project Fire Alarm Contractor to ensure proper air flow sampling and differential pressure.

3.03 DUCTWORK AIR LEAKAGE TESTING

A. Dust leakage testing is required on all ductwork constructed to 4" wg class and higher.

B. Test and balance agency shall perform active air flow testing of ductwork systems or sections of ductworks. Agency shall inspect and confirm that all ductwork is sealed per the specification requirements prior to performing any testing. Calculate maximum allowable air leakage by system based on total design air flow rate and/or square footage of ductwork. Maximum allowable system air flow leakage shall not exceed 5% of total air volume, or the maximum allowable per local energy or mechanical codes where the allowable limit is less than 5%.

C. Representative sections totaling 10 percent, or greater, of the total installed duct area shall be tested. Where the tested 10 percent fails to comply with the requirements, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fails to comply then 100 percent of the total installed duct area shall be tested and verified to have a leakage rate that does not exceed the maximum allowable limit. Duct sections shall be selected by the Owner's Representative. Obtain total duct surface area and air flow volumes for each duct section from the installing contractor. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

D. Additional ductwork leakage testing may be required to meet local energy and mechanical code requirements. Refer to local codes for applicability and requirements.

E. Ductwork systems to be leakage tested and procedures shall include:

1. Testing shall be performed at 1.5 times the peak design outlet static pressure (external static pressure) from the air handling unit/fan, but not greater than the maximum SMACNA pressure rating of the ductwork construction classification.
2. Testing is not required of flexible ductwork or ductwork downstream of VAV terminal units.
3. Leakage through manufactured products, such as air handling units, dampers, fire/smoke dampers and terminal units may be excluded from the leakage calculations based on manufacturer stated values, at pressure, or these units may be temporarily sealed with painter's tape or plastic sheeting during testing to seal any openings and must be removed after testing.

4. Supply air ductwork from the outlet of the air handling unit/fan to inlet side of terminal units or connection to flexible ductwork. Duct leakage testing is not required downstream of terminal units.
5. All supply, return and exhaust air ductwork located outside the building envelope.
6. Return and exhaust air ductwork located in unconditioned spaces from inlet of the air handling unit/fan to the ductwork terminations upstream of each return air grille.

F. For buildings under the jurisdiction of the UMC or CMC provide duct leakage testing in compliance with maximum allowable leakage quantities per code Section 603 and in no case greater than 5% of the total system air flow volume. Ductwork shall be leak-tested in accordance with the procedures described in SMACNA HVAC Air Duct Leakage Test Manual. The permitted duct leakage shall be not more than the following:

1. $L_{MAX} = C_L P^{0.65}$ where:
   a. L_{MAX}=maximum permitted leakage (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area.
   b. $C_{L=}$ Six (6), SMACNA duct leakage class (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area at 1 inch water column (0.2 kPa).
   c. P=test pressure, which shall be equal to the design duct pressure class rating in inches of water column (kPa).

G. Ductwork installer shall prepare ductwork for pressure testing as deemed appropriate to maintain construction schedule. Ductwork may be tested as total systems or in sections. Sectional testing will require documentation to prove the totalized system leakage is within allowable range of entire system. Ductwork inlets and outlets may be temporarily sealed airtight with plastic, or other means, to facilitate testing pressures.

H. Testing may occur through ductwork devices such as balancing dampers, smoke fire dampers and coils. Manufacturer provided air leakage allowances for such devices may be excluded from duct leakage measurement but must be documented in final report.

I. The leakage rate shall be confirmed through field verification and diagnostic testing in accordance with procedures defined by Oriflow Air Leakage Test, or equivalent procedure. Perform all testing utilizing a duct leakage testing system, Oriflow Duct Leakage Tester or equal, with calibrated fan, orifice, gauges, ductwork, pressure tips and tubing.

3.04 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide design air quantity to or through, each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant air conditions.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).

1. Balancing between runs (submains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.
2. Restriction imposed by flow regulating devices in or at terminals shall be minimal.

3. Final measurements of air quality shall be made after the air terminal has been adjusted to provide the optimum air pattern of diffusion and as indicated on the air distribution drawings.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system's total flow may be used only for systems with direct-connected fans (without adjustable pitch blades), provided system pressure is less than 0.5" w.g. and sound level criteria are met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.

1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE "Handbook Fundamentals Inch Pound Edition."
2. For ducts serving modular office areas with movable partitions, which are subject to change, pitot tube traverses may be omitted provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of pitot tube traverses, airflow in the duct shall be determined by totaling volume of individual terminals served, measured as described herein.
3. Where duct's design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove accuracy of testing methodology and test data when so directed. Such tests shall be conducted in conformance with applicable ASHRAE or American Society of Mechanical Engineers (ASME) codes and shall be performed at no additional cost to Owner.

H. Air Motion: Air motion and distribution shall be as specified and indicated on drawings. The Contractor, at no additional cost to the Owner shall, in addition to air motion and direct measurements, perform smoke tests as requested to demonstrate the air distribution and pattern from air terminals and outlets.

I. Air system test and balance procedures shall include, but not be limited to the following requirements:

1. Test and adjust blower RPM to design requirements.
2. Test and record motor full load amperes.
3. Make pitot tube traverse of main supply ducts and obtain design CFM at fans.
4. Test and record system static pressures, suction pressure directly at system fan inlet, and outlet pressure directly at system fan outlet or discharge. Test and record static pressure across each component of air handling system (coils, filters, etc.).
5. Test and adjust system for design CFM recirculated air.
6. Test and adjust system for design CFM outside air.
7. Test and record entering air temperatures.
8. Test and record leaving air temperatures.

9. Adjust all supply, return and exhaust air ducts to proper design CFM.
10. Adjust all zones to proper design CFM, supply and return.
11. Test and adjust duct systems and each diffuser, grille, and/or register to within 10% of design requirements.
12. Each grille, diffuser and register shall be identified as to location and area.
13. Operate each variable frequency drive (VFD) and verify controls installation is complete.
14. Size, type and manufacturer of VAV boxes, diffusers, grilles, registers and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.
15. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustment.
16. In cooperation with the control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Testing agency shall check all controls requiring adjustment by control installers. Room thermostats shall be checked for cooling and heating response.
17. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.
18. Adjust overall system balances to allow all self-closing exterior doors to close from any open position. Maximum interior air pressure in all operational modes shall not exceed 0.05" static pressure relative to the outside air pressure. Comply with chapter 10 of the Building Code to assure that self-closing doors will release with a maximum force of 15 pounds.
19. As part of the work of this contract, the HVAC contractor shall make any changes in the pulleys, belts and dampers or the addition of dampers required for correct balance as recommended by air balance agency, at no additional cost to Owner.
20. After air balancing is completed and RPM determined, HVAC Contractor shall provide fixed pitch pulleys.
21. All mixing boxes, VAV air valves, control dampers, smoke dampers and similar devices which operate at 100% shut off shall be tested for leakage.
22. Variable Air Volume Fan Systems: The primary balancing mode is 100% outside air with all terminal boxes on a full call for cooling. Also check and record performance at minimum outside air with all terminal boxes on call for full cooling and at minimum outside air with all terminal boxes on call for full heating and at minimum outside air in the deadband range with no call for heating or cooling. Verify that the systems are operating on a stable part of the fan curves in each mode. Record final duct static controller settings.
23. Space Pressurization Procedure:
    a. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
    b. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
    c. Measure space pressure differential where pressure is used as the design criteria and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
        1) For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
        2) For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.

3) Test room pressurization first, then zones, and finish with building pressurization.

d. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

e. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
   1) Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
   2) Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test over pressurization and under pressurization, and observe and report on the system's ability to revert to the set point.
   3) For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

f. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

g. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.05 ADA COMPLIANCE

A. All air balancing work shall be coordinated with other disciplines to comply with meeting or exceeding the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, State Energy Code and local amendments. Final air balancing for all systems in each space shall be verified and adjusted as necessary to meet the following requirements during peak ventilation, smoke control mode, partial ventilation and minimum ventilation modes during occupied and non-occupied hours. The following requirements are provided as consolidated list of minimum ADA requirements:

1. The required force for pushing or pulling open a door other than fire doors shall not exceed 5 pounds.
2. At fire doors the required opening force shall not exceed 15 pounds.
3. At fire doors the doors shall be set in motion when subjected to a force not exceeding 30 pounds.
4. At fire doors the doors shall swing to a full open position when subjected to a force not exceeding 15 pounds.
5. The force to operate door latch releases shall not exceed 5 pounds.
6. The differential pressure between the building lobby and outside shall remain positive between 0.01” w.g., minimum, and 0.05” w.g., maximum, during operational hours.

3.06 AIR SYSTEM DATA

A. Report: The certified report shall include for each air handling system the data listed below.

1. Equipment (Fan or Factory Fabricated Station Unit):
   a. Installation data
      1) Manufacturer and model
      2) Size

3) Arrangement, discharge and class
4) Motor hp, voltage, phase, cycles, and full load amps
5) Location and local identification data

b. Design data
1) Data listed in schedules on drawings and specifications.

c. Fan recorded (test) data
1) CFM
2) Static pressure (suction and discharge, across each coil and filter set)
3) RPM
4) Motor operating amps
5) Motor operating bhp

2. Duct Systems:
a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor (outside) air, total air, and exhaust:
1) Duct size(s)
2) Number of pitot tube (pressure measurements)
3) Sum of velocity measurements (Note: Do not add pressure measurements)
4) Average velocity
5) Recorded (test) cfm
6) Design cfm

b. Individual air terminals
1) Terminal identification supply or exhaust, location and number designation
2) Type size, manufacturer and catalog identification applicable factor for application, velocity, area, etc., and designated area
3) Design and recorded velocities - fpm (state "core," "inlet," etc., as applicable)
4) Design and recorded quantities - cfm (deflector vane or diffusion cone settings)

3.07 WATER SYSTEM PROCEDURES

A. Preparation:

1. Open all valves to fully open position. Close coil bypass stop valves. Set mixing valve to full coil flow.
2. Remove all strainers and clean same. Reinstall.
3. Examine water system and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Check expansion tank to determine they are not air bound and the system is completely full of water.
6. Check all air vents at high points of water systems and determine that all are installed and operating freely.
7. Check operation of automatic bypass valve.
8. Operate each variable frequency drive (VFD) and verify controls installation is complete.
9. Check and set operating temperatures of all equipment at design requirements.
10. Complete air balance must have been accomplished before actual water balance begins.

B. Adjustment: All heating, cooling and condensing water systems shall be adjusted to provide required quantity to or through each component.

C. Metering: Water quantities and pressures shall be measured with calibrated meters.

1. Venturi tubes, orifices, or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils except room units, converters, etc.) prior to the capacity testing.
2. Where flow metering fittings are not installed, in air/water type heat transfer equipment, flow balance shall be determined by measuring the air side energy differential across the heat transfer equipment. Measurement of water temperature differential shall be performed with the air system, adjusted as described herein, in operation.

D. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests.

E. Flow: Flow through bypass circuits at three-way valves shall be adjusted to equal that through the supply circuit, when the valve is in the bypass position.

F. Distribution: Adjustment of distribution shall be affected by means of balancing devices (cocks, valves, and fittings) and automatic flow control valves as provided. Manual service valves shall not be used for balancing.

1. Where automatic flow control valves are utilized in lieu of Venturi tubes, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

G. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

H. Water System Test and Balance Procedure: Perform the following tests, and balance each system in accordance with the following requirements:

1. Set heating water pumps to proper gallons per minute delivery.
2. Adjust heating water flow through boiler(s).
3. Test and record entering and leaving water temperatures through boilers
4. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
5. After adjustments to coils are made, recheck settings at the pumps, boilers, and readjust if required.
6. Record and check the following items at each coil.
    a. Inlet water temperatures.
    b. Leaving water temperatures.
    c. Water pressure drop of each coil.
7. Pump operating suction and discharge pressures and final total dynamic head.
8. List all mechanical specifications of pumps.
9. Rated and actual running amperage of pump motor.
10. Water metering device readings.

3.08 WATER SYSTEM DATA

A. Report: The certified report for reach water system shall include the data listed below.

1. Pumps:
   a. Installation data
      1) Manufacturer and model
      2) Size
      3) Type drive
      4) Motor hp, voltage, phase, and full load amps
   b. Design data
      1) GPM
      2) Head
      3) RPM and amps
   c. Recorded data
      1) Discharge pressures (full-flow and no-flow)
      2) Suction pressures (full-flow and no-flow) operating head
      3) Operating gpm (from pump curves if metering is not provided) no-load
      4) Amps
      5) Full-flow amps
      6) No-flow amps

2. Air Heating and Cooling Equipment:
   a. Design data
      1) Load in Btuh or MBh
      2) GPM
      3) Entering and leaving water temperature
      4) Entering and leaving air conditions (DB and WB)
      5) CFM
      6) Water pressure drop
   b. Recorded data
      1) Type of equipment and identification (location or number designation)
      2) Entering and leaving air conditions (DB and WB)
      3) Entering and leaving water temperatures
      4) GPM
      5) Temperature rise or drop

3. Water Chilling Units:
   a. Installation data
      1) Manufacturer and model
      2) Motor hp, voltage, cycles, phase, and full load amps
      3) Part load amperes
      4) GPM - chiller and condenser
      5) Water pressure drop - chiller and condenser
      6) Entering and leaving water temperature - chiller and condenser
   b. Recorded data (chiller and condenser)
      1) GPM
      2) Water pressure drop
      3) Entering and leaving water temperature
      4) Amperes

4. Boilers:
    a. Installation data
        1) Manufacturer and model
        2) Motor hp, voltage, cycles, phase, and full load amps
        3) Part load amperes
        4) GPM
        5) Water pressure drop
        6) Entering and leaving water temperature
    b. Recorded data
        1) GPM
        2) Water pressure drop
        3) Entering and leaving water temperature
        4) Amperes

3.09 SOUND TEST PROCEDURES

A. Scope: Tests of sound levels shall be made at each selection point as described in the following:

1. Each normally occupied room or space, including, but not limited to, the following:
    a. Offices, open and enclosed.
    b. Conference rooms and breakout rooms.
    c. Lobbies and waiting rooms.
    d. Break rooms.
    e. Retail spaces.
    f. Dining area.
    g. Hospitality spaces, guest rooms and patient rooms.
    h. IT and data equipment rooms.

2. Within five feet of each piece of noise generating equipment, such as chillers, cooling towers/fluid coolers, fans, compressors, pumps, and condensers. Or, within the documented sound measurement distance as listed in the equipment manufacturer literature.
3. Within five feet of property lines where mechanical equipment is located outside the building.

B. Timing: Sound level measurements shall be taken at times when the building is unoccupied, or when activity in surrounding areas and background noise level in areas tested are at a minimum and relatively free from sudden changes in noise levels.

1. Measurements shall be taken with all equipment turned off, except that being tested.
2. The required sound levels shall be measured at any point within a room not less than 6 feet from any equipment or air terminal and not closer than 3 feet from any floor, wall, or ceiling surface.

C. Meters: Sound levels shall be measured with a sound meter complying with ANSI S1.4. The "A" scale shall be used to measure over all sound levels. To determine the specified octave band levels, the above sound level meter, set on "C" scale, shall be supplemented by an octave band analyzer complying with ANSI S1.11.

D. Equipment Components: The "Equipment Component" of room sound equals LPt-C. The "Equipment Component" of room sound (noise) levels shall be determined for each of eight octave bands as follows:

1. Measure room sound pressure level "LPb" with equipment to be tested shut off.
2. Measure room sound pressure level "LPt" with equipment to be tested turned on.
3. Calculate LPt-LPb; if this value is less than 1, applicable test must be rerun with lower background level (LPb) unless LPt is within sound pressure level specified for equipment.
4. Determine "c" from the table below.

LPt-LPb (db)	c (db)
1	7
2	4
3	3
4 to 4- ½	2
5 to 5- ½	1 – ½
6 to 7- ½	1
8 to 12	½
over 12	0

3.10 SOUND LEVEL DATA

A. Report: Certified report shall record data on sound levels, taken at each selected location, as follows:

1. Source of sound and location.
2. Diagram or description of relationship of sound source to measuring instrument.
3. "A" scale readings equipment being tested turned off (ambient) equipment being tested turned on (operating conditions).
4. Readings at each specified octave band frequency for equipment being tested turned off (ambient level) and equipment being tested turned on (operating conditions).
5. "Equipment Components" of sound (noise) levels with applicable calculations per "Sound Test Procedures".
6. Graph showing relationship between pressure levels specified and recorded readings

B. Retest: Subsequent to any correctional construction work, such as acoustic corrections, measurement shall be made to verify that associated air and water quantities, as previously measured, have not been disrupted.

1. Certified report shall record all sound data, and their locations, after final adjustments of air and water systems involves

3.11 BALANCING MEASUREMENT TOLERANCES

A. Comply with codes and standards applicable for this project and local AHJ.

B. Comply with maximum tolerance air balance limitations listed in the ASHRAE Handbook – HVAC Applications (latest edition) and as listed in the following guidelines:

1. Air terminal units: -2% to +10% of design air flows.
2. Minimum Outside Air: -2% to +10% of design air flows.

3. For negative pressure rooms: 0% to +10% or design exhaust air flows and balance supply air from -10% percent to 0% of design supply air flows.
4. For positive pressure rooms: 0% to +10% of supply air flows and balance exhaust/return form -10% to 0% of design air flows.
5. For rooms with less than 200 cfm, that are not indicated by plans or code to be positive or negative, balance the supply/return/exhaust from -5% to +5% of design air flows.
6. Supply fans, return fans, exhaust fans and equipment with fans: 0% to +10% of design air flows.
7. Air outlets and inlets: -/+ 5% of design air flows.
8. Preheat heating water flow rate: 0% to +10% of design water flows.

3.12 CERTIFIED REPORTS

A. Submittals: Six (6) copies of the reports described herein, covering air and water system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious malfunction and design deficiencies.

D. Certification: Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.13 FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

A. Scope: Test shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.

1. At the time of final inspection, the Contractor shall recheck, random selection of data (water and air quantities, air motion, and sound levels) recorded in the certified report. In addition, all courtrooms, auditoriums, and conference rooms shall be rechecked.
2. Points and areas for recheck shall be selected by the commissioning team.
3. Measurement and test procedures shall be the same as approved for work forming basis of certified report.
4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from design, or a sound level greater than 2 db or more than recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the

Contractor so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION 230593

SECTION 230713 – DUCT INSULATION

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:

1. Ductwork Insulation:
   a. Duct wrap insulation.
   b. Rigid board ductwork and plenum insulation.
   c. Fire Rated duct insulation systems.
   d. Field applied jackets, indoor and outdoor.

2. Section Includes insulating the following duct services:
   a. All supply air ductwork, unless otherwise shown on drawings.
   b. Return air ductwork in unconditioned spaces and as shown on drawings.
   c. Acoustical duct lining, in vertical/horizontal supply and return ducts within twenty feet (20') of air handling equipment and where otherwise shown on drawings. Applicable to all new ductwork.
   d. Outside air ductwork in return plenums, mechanical rooms and in freezing climates.
   e. Exhaust air ductwork in cold air plenums.
   f. Insulation to protect fire rated exhaust systems.

3. Plenums and equipment rooms, as noted.

B. Types of mechanical insulation specified in this Section include the following:

1. Duct wrap insulation: Glass mineral wool also known as fiberglass.
2. Duct wrap insulation: Flexible elastomeric foam.
3. Acoustic duct liner: Glass mineral wool also known as fiberglass.
4. Acoustic duct liner: Flexible elastomeric foam.
5. Acoustic duct liner: Polyimide foam.
6. Rigid board duct and plenum insulation: Calcium silicate.
7. Rigid board duct and plenum insulation: Glass mineral wool.
8. Fire-rated duct insulation: Calcium silicate.
9. Fire-rated duct insulation: Fire-rated board.
10. Fire-rated duct insulation: Fire rated blanket.
11. Insulation jackets.
12. Removable covers
13. Insulation accessories.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 233113: Air Distribution.

1.04 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

C. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

D. Freezing Climate: Where outdoor design temperature is less than 33° F, as stated in ASHRAE fundamentals under 99% column for winter design conditions.

E. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.05 INSULATION INDUSTRY DEFINITIONS

A. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a Kraft paper interleaving with an outer film layer leaving no paper exposed.

B. ASJ: All Service Jacket (no outer film).

C. EPA: Environmental Protection Agency.

D. FHC: Fire Hazard Classification

E. FSK: Foil-Scrim-Kraft facing or vapor barrier.

F. FSP: Foil-Scrim-Polyethylene facing or vapor barrier.

G. ECOSE Technology: a proprietary binder system based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. ECOSE Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

H. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the "worst in class" materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

I. PSK: Polypropylene-Scrim-Kraft facing or vapor barrier.

J. PVC: Polyvinyl Chloride.

K. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

L. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

M. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

N. SVF: Synthetic Vitreous Fiber including all forms of manufactured inorganic fibrous insulations such as glass wool (fiberglass) and mineral wool (rock wool and slag wool).

O. SSL+: Self-Sealing Lap with Advanced Closure System.

P. SSL: Self-Sealing Lap.

Q. Underwriter's Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

S. UL Environment Claims Validation (ECV): service and label tests a manufacturer's product and validates that the environmental claims they make in their marketing and packaging materials are factual.

T. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

U. UL GREENGUARD Gold Certification: (formerly known as GREENGUARD Children & Schools Certification) offers stricter certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by both The Collaborative for High Performance Schools (CHPS) and the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

1.06 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
   a. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C165: Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
   c. C167: Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.

d. C168: Terminology for Thermal Insulation.
e. C177: Test Method for Steady-State Heat Flux Measurements and Thermal Transmission by Properties by Means of the Guarded Hot Plate Apparatus.
f. C195: Specification for Mineral Fiber Thermal Insulating Cement.
g. C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
h. C302: Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
i. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.
j. C305: Test for Thermal Conductivity of Pipe Insulation.
k. C356: Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
l. C411: Test for Hot-Surface Performance of High Temperature Thermal Insulation.
m. C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
n. C449: Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
o. C518: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p. C533: Specification for Calcium Silicate Block and Pipe Thermal Insulation.
q. C534: Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
r. C547: Specification for Mineral Fiber Preformed Pipe Insulation.
s. C552: Specification for Cellular Glass Block and Pipe Thermal Insulation.
t. C612: Specification for Mineral Fiber Block and Board Thermal Insulation.
u. C755: Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.
v. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
w. C916: Standard Specification for Adhesives for Duct Thermal Insulation.
x. C921: Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
y. C1104: Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
z. C1071: Standard Specification for Thermal and Acoustical Insulation.
aa. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
bb. C1290: Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
cc. C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
dd. D1667: Standard Specification for Flexible Cellular Material-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
ee. E84: Test Method for Surface Burning Characteristics of Building Materials.
ff. E119: Test for Fire Resistance.
gg. G21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
hh. G22: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.
ii. EE2336: Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90: Energy Conservation in New Building Design.

3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255: Test Methods, Surface Burning Characteristics of Building Materials.

4. Underwriters Laboratory (UL): Manufacture and test insulation in accordance with the UL Standards, including:
   a. 181: Standard for Factory-Made Air Ducts and Air Connectors.
   b. 723: Standard for Test for Surface Burning Characteristics of Building Materials.
   c. 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

B. 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.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Materials exposed within ducts or plenums shall be noncombustible. Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

E. Corrosiveness: Passes ASTM C1617-05, Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

1.07 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also, furnish necessary test data certified by an independent testing laboratory. Submit samples.

1. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by

mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
a. Pentabrominated diphenyl ether (CAS#32534-81-9).
b. Octabrominated diphenyl ether (CAS#32536-52-0).
c. Decabrominated diphenyl ether (CAS#1163-19-5).

2. All materials, adhesives, mastics and sealants installed in California shall meet or exceed the minimum testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing and Evaluation of Volatile Organic Emissions from Indoor Sources using Environmental Chambers."

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Comply with requirements in "PART 3 – EXECUTION" for Table 1, Table 2 and Table 3 for application of insulation materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold if possible.

C. Insulation materials for use on austenitic stainless steel shall be qualified per ASTM C795.

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

E. Each insulation material has been provided a descriptive key code, such as **DW-A**, to simplify the organization and application of materials in following sub-sections.

F. Acceptable manufacturers include Knauf, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco,

Reflectix or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.02 DUCT WRAP INSULATION (IDENTIFIED BY KEY CODE **DW** AND IN TABLE 1)

A. **DW-A,** Flexible Glass Mineral Wool Blanket:

1. Application: Exterior insulation wrap for ductwork or other HVAC systems.
2. Flexible Glass Mineral Wool Blanket bonded with a bio-based thermosetting resin:
3. Comply with ASTM C553, ASTM C1290, UL 723, and UL Greenguard certified.
4. K-value: 0.29 Btu•in./(hr.•ft²•°F) at 75°F installed full thickness (maximum). Equivalent to "R-Value" per inch of 3.4 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: 0.75 lb./cu.ft. (minimum).
6. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft. Or, PSK (Polypropylene-Scrim-Kraft) plastic vapor barrier.
7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" section.
8. Maximum operating temperature: 250°F.
9. Flame spread index: ASTM E84, less than 25.
10. Smoke developed index: ASTM E84, less than 50.
11. Manufacturers: Knauf Insulation #Atmosphere Duct Wrap, Owens Corning #SOFTR Duct Wrap, Johns Manville #Microlite FSK or PSK or equal.

B. **DW-B,** Elastomeric Foam Flexible Insulation:

1. Application: Exterior insulation wrap for ductwork or other HVAC systems.
2. Elastomeric foam insulation with acrylic polymer airstream coating.
3. Comply with ASTM D1622, ASTM C1104, ASTM C518, and UL Greenguard Low VOC certified.
4. K-value: 0.25 Btu•in./(hr.•ft²•°F) at 75°F per ASTM C518. Equivalent to "R-Value" per inch of 4.0 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: ASTM D 1622, 3.0-6.0 lb./ft3.
6. Water vapor sorbtion: ASTM C 1104, less than 2% by weight.
7. Fungal and bacteria resistance: ASTM G 21/22, no growth.
8. Maximum operating temperature: 250°F.
9. Flame spread index: ASTM E84, less than 25.
10. Smoke developed index: ASTM E84, less than 50.
11. Adhesive: UL listed waterproof type compliant with ASTM C916.
12. Manufacturers: Armacell #AP Armaflex and #AP Coilflex or equal.

C. **DW-C,** Black PSK-Faced Flexible Glass Mineral Wool Blanket for Visible Exposed Ducts:

1. Application: Exterior insulation wrap for exposed ductwork or other HVAC systems.
2. Flexible Glass Mineral Wool Blanket bonded with a bio-based thermosetting resin:
3. Comply with ASTM C553, ASTM C1290, UL 723, and UL Greenguard certified.
4. K-value: 0.29 Btu•in./(hr.•ft²•°F) at 75°F installed full thickness (maximum). Equivalent to "R-Value" per inch of 3.4 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: 0.75 lb./cu.ft. (minimum).
6. Vapor Barrier Jacket: Black PSK (Polypropylene-Scrim-Kraft) faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft.
7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" section.
8. Maximum operating temperature: 250°F.

9. Flame spread index: ASTM E84, less than 25.
10. Smoke developed index: ASTM E84, less than 50.
11. Manufacturers: Johns Manville #Microlite Black PSK or equal.

2.03 ACOUSTIC DUCT LINER (IDENTIFIED BY KEY CODE **ADL** AND IN TABLE 3).

A. **ADL-A,** Glass Mineral Wool Acoustic Duct Liner:

1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Fiberglass acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.24 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to "R-Value" per inch of 4.2 (hr.•ft²•°F)/Btu•in. (minimum).
6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.70 based on ASTM C423 Type "A" mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
14. Manufacturers: Johns Manville #Linacoustic RC, Knauf Insulation #Atmosphere with ECOSE, Owens Corning #QuietR Duct Liner HD or Duct Liner Board or equal.

B. **ADL-B,** Flexible Elastomeric Foam Duct Liner:

1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Elastomeric foam insulation with acrylic polymer airstream coating.
3. K-value: ASTM C518, 0.27 Btu•in./(hr•ft²•°F) at 75°F per ASTM C518. Equivalent to "R-Value" per inch of 3.7 (hr.•ft²•°F)/Btu•in. (minimum).
4. Density: ASTM D 1622, 3.0-6.0 lbs./ft^3.
5. Water vapor absorption: ASTM C209, less than 0.2% by weight.
6. Fungal and bacteria resistance: ASTM G21/22, no growth.
7. Noise Reduction Coefficient: ASTM C 423, 0.49 or higher based on "Type A mounting".
8. Maximum Velocity on Mat or Coated Air Side: 5,000 ft/min.
9. Maximum operating temperature: 220°F.
10. Flame spread index: ASTM E84, less than 25.
11. Smoke developed index: ASTM E84, less than 50.
12. Adhesive: UL listed waterproof type compliant with ASTM C916.
13. Greenguard certified, low VOC.
14. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
15. Manufacturers: Armacell #Armaflex Ultra or equal.

C. **ADL-C,** Polyimide Foam Acoustic Duct Liner:

1. Application: Internal insulated duct lining for acoustic or thermal purposes.
2. Greenguard certified, low VOC.
3. Polyimide foam insulation with acrylic polymer airstream coating.

4. K-value: ASTM C518, 0.30 Btu•in./(hr•ft²•°F) at 75°F per ASTM C518. Equivalent to "R-Value" per inch of 3.3 (hr.•ft²•°F)/Btu•in. (minimum).
5. Density: ASTM D 3574, 0.80 lbs./ft^3.
6. Water vapor absorption: ASTM C1104, less than 2% by weight.
7. Fungal and bacteria resistance: ASTM G21/22, no growth.
8. Noise Reduction Coefficient: ASTM C423, 0.70 or higher based on "Type A mounting".
9. Maximum Velocity on Mat or Coated Air Side: 5,000 ft/min.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Adhesive: UL listed waterproof type compliant with ASTM C916.
14. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
15. Manufacturers: Boyd Corporation #SOLCOUSTIC or equal.

D. **ADL-D,** Round Duct Liner:

1. Application: Internal insulated round duct lining for acoustic or thermal purposes.
2. Fiberglass acoustical duct liner bonded with a bio based thermosetting resin.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.23 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to "R-Value" per inch of 4.3 (hr.•ft²•°F)/Btu•in. (minimum).
6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type "A" mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Factory-formed grooves at sufficient intervals to prevent air gaps between back of insulation and spiral duct surface.
14. Manufacturers: Owens Corning #QuietZone Spiral Duct Liner, Johns Manville #Spiracoustic Plus or equal.

2.04 RIGID FIBERGLASS BOARD DUCTWORK AND PLENUM INSULATION (IDENTIFIED BY KEY CODE **RB** BELOW AND IN TABLE 2)

A. **RB–A,** Rigid fiberglass duct board:

1. Application: Rigid duct boards for insulating metal plenums and metal ductwork where rigidity is required.
2. Fiberglass duct board with a bio based thermosetting resin.
3. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
4. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
5. K-value: 0.23 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to "R-Value" per inch of 4.3 (hr.•ft²•°F)/Btu•in. (minimum).
6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type "A" mounting.

8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
11. Flame spread index: ASTM E84, less than 25.
12. Smoke developed index: ASTM E84, less than 50.
13. Density: 3.0 lbs./cu ft. (minimum).
14. Vapor Barrier Jacket: ASJ+ (All Service Jacket) or FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft paper.
15. Manufacturers: Knauf #Atmosphere Air Duct Board, Johns Manville #SuperDuct RC, Owens Corning #QuietR Duct Board, Certainteed #Ultra*Duct or equal.

2.05 FIRE-RATED INSULATION SYSTEMS

A. **FRI-A,** Hydrous Calcium Silicate for wrapping exhaust pipes and mufflers from generators and engines:

1. Rigid Molded Block Insulation: Asbestos-Free Coded Throughout Material Thickness and Maintained Throughout Temperature Range. ASTM C5333 compliant.
2. "K" Value: 0.397 Btu•in./(hr.•ft²•°F) at 300°F. Equivalent to "R-Value" per inch of 2.5 (hr.•ft²•°F)/Btu•in. (minimum).
3. Maximum Service Temperature: 1,200°F.
4. Compressive Strength (block): Minimum of 100 psi to produce 5% compression.
5. Tie Bands: Secure blocks in places with staggered joints using 3/8" or 1/2" stainless steel bands on 12" centers.
6. Manufacturers: Johns Manville #Thermo-12 Gold or equal.

B. **FRI-B,** Fire Barrier Duct Wrap for Type I, commercial, kitchen hood exhaust ductwork:

1. High-temperature, flexible, blanket insulation with FSK jacket that is NRTL (Nationally Recognized Test Lab) tested and certified to provide a 2-hour fire rating. Apply two overlapping layers for grease ducts.
2. Compliant with ASTM E2336.
3. Density (minimum): 6 lb./cu.ft.
4. Thickness (minimum): 1.5" thick (38 mm).
5. "R-value" per inch thickness (minimum): ASTM C518, 4.0 (hr•ft²•°F) / Btu at 75°F.
6. Maximum operating temperature: 2192°F (1200°C).
7. Flame spread index: ASTM E84, less than 25.
8. Smoke developed index: ASTM E84, less than 50.
9. Manufacturers: 3M #Fire Barrier Duct Wrap 615+, Morgan #FireMaster FastWrap XL, Morgan #Pyroscat DuctWrap XL, Unifrax #FyreWrap Elite 1.5 or equal.

C. **FRI-C,** Fire-Rated Board:

1. Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700°F (927°C).
2. Comply with ASTM C656, Type II, Grade 6.
3. Compliant with ASTM E119, ASTM E814, UL 263, UL 1479, UL 1709 and NFPA 251 for one and two hour fire protection.
4. Flame spread index: ASTM E84, equal to 0.
5. Smoke developed index: ASTM E84, equal to 0.
6. Density (minimum): 28 lb./cu.ft.
7. "R-Value" per inch thickness (minimum): ASTM C518, 1.7 (hr•ft²•°F) / Btu at 75°F.

8. Manufacturers: Johns Manville #Super Firetemp M or equal.

D. **FRI-D,** Fire Barrier Duct Wrap for ventilation ducts:

1. High-temperature, flexible, blanket insulation with FSK jacket that is NRTL (Nationally Recognized Test Lab) tested and certified to provide a 1-hour or 2-hour fire rating. Apply one layer for ventilation (supply, return, environmental exhaust) ducts and life safety ducts.
2. Compliant with ISO 6944.
3. Density (minimum): 6 lb./cu.ft.
4. Thickness (minimum): 1.5" thick (38 mm).
5. "R-Value" per inch thickness (minimum): ASTM C518, 4.0 (hr•ft²•°F) / Btu at 75°F.
6. Maximum operating temperature: 2192°F (1200°C).
7. Flame spread index: ASTM E84, less than 25.
8. Smoke developed index: ASTM E84, less than 50.
9. Manufacturers: 3M #Fire Barrier Duct Wrap 615+, Morgan #FireMaster FastWrap XL, Morgan #Pyroscat DuctWrap XL, Unifrax #FyreWrap Elite 1.5 or equal.

E. **FRI-E,** Fire Barrier Plenum Wrap for encapsulating non-rated (plastic) pipes and cables:

1. High-temperature, flexible, blanket insulation with FSK jacket that is NRTL (Nationally Recognized Test Lab) tested and certified. Apply one layer blanket to wrap combustible items in an air plenum area.
2. Density (minimum): 8 lb./cu.ft.
3. Thickness (minimum): 0.5" thick (13 mm).
4. Maximum operating temperature: 2300°F (1260°C).
5. Flame spread index: ASTM E84, less than 25.
6. Smoke developed index: ASTM E84, less than 50.
7. Manufacturers: 3M #Fire Barrier Duct Wrap 5A+, Unifrax #FyreWrap 0.5 Plenum Insulation, Morgan #FireMaster PlenumWrap or equal.

2.06 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. Flexible Elastomeric and Polyolefin Adhesive:

1. Comply with MIL-A-24179A, Type II, Class I.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: Aeroflex #Aeroseal, Armacell #Armaflex 520, H.B.Fuller #Foster 85-75, K-Flex #720-LVOC or equal.

C. Mineral-Fiber Adhesive:

1. Comply with MIL-A-3316C, Class 2, Grade A.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries # 22 Series or equal.

D. ASJ+ Adhesive, and FSK Jacket Adhesive:

1. Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
2. 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).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries #22 Series or equal.

E. PVC Jacket Adhesive:

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturer: Dow Corning #739 Plastic Adhesive, Johns Manville #Zeston Perma-Weld, Speedline #Polyco Adhesive Low VOC or equal.

2.07 MASTICS

A. Materials shall be compatible with ductwork material, insulation materials, jackets, and substrates and for sealing joints and seams.

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

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).

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

1. Water-Vapor Permeance: ASTM E96/E96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: -20°F to +180°F (-29°C to +82°C).
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Foster 30-90, Vimasco #749 Vapor-Blok or equal.

D. Vapor-Barrier Mastic: Solvent based; suitable for indoor use.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
2. Service Temperature Range: 0 to 180°F (Minus 18 to plus 82°C).
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Childers CP-30, H.B.Fuller #Foster 30-35, Mon-Eco Industries #55-10 or equal.

E. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use for below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

4. Color: White.
5. Manufacturer: H.B.Fuller #Foster 60-95/60-96 or equal.

F. Breather Mastic: Water based; suitable for indoor and outdoor use for above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.
5. Manufacturer: H.B.Fuller #Childers CP-10, H.B.Fuller #Foster 46-50, Mon-Eco Industries #55-50, Vimasco #WC-1 or WC-5 or equal.

2.08 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 1241°C).
4. Color: Aluminum.
5. 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).
6. Manufacturer: H. B. Fuller Company #Childers CP-76, Eagle Bridges - Marathon Industries #405, H. B. Fuller Company #Foster 95-44, Mon-Eco Industries, Inc.#44-05 or equal.

B. ASJ+ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.
5. 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).
6. Manufacturer: H. B. Fuller Company #Childers CP-76 or equal.

2.09 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth

of insulation indicated. Manufacturer: AGM Industries, Inc. #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer. Manufacturer: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
    b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
    d. Manufacturer: AGM Industries #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners #Spindle or equal.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
    b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
    d. Manufacturer: GEMCO #Nylon Hangers, Midwest Fasteners #Nylon Insulation Hangers or equal.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
    b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12-gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
    c. Adhesive-backed base with a peel-off protective cover.
    d. Manufacturer: AGM Industries #Tactoo Self-Adhering Insul-Hangers, GEMCO; #Peel & Press, Midwest Fasteners #Self Stick or equal.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless steel sheet, as coordinated with application

with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
   b. Manufacturer: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Manufacturer: GEMCO, Midwest Fasteners or equal.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel

2.10 LAGGING ADHESIVES

A. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

B. 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 per 40 CFR 59, Subpart D (EPA Method 24).
2. Service Temperature Range: 0 to +180°F (-18°C to +82°C).
3. Color: White.
4. Manufacturer: H.B.Fuller #Childers CP-50, H.B.Fuller #Foster 30-36, Vimasco #713 or 714 or equal.

2.11 TAPES

A. ASJ+ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf./inch (7.2 N/mm) in width.
6. ASJ+ Tape Disks and Squares: Precut disks or squares of ASJ+ tape.
7. Manufacturer: ABI Ideal Tape #428 AWF ASJ+, Avery Dennison Corporation Specialty Tapes Division #Fasson 0836, Compac Corporation #104 and 105, Venture Tape #1540 CW Plus, #1542 CW Plus, and #1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
7. Manufacturer: ABI Ideal Tape #491 AWF FSK, Avery Dennison Corporation Specialty Tapes Division #Fasson 0827, Compac Corporation #110 and 111, Venture Tape #1525 CW NT, #1528 CW, and #1528 CW/SQ or equal.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications and UL 723 compliant.

1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
6. Manufacturer: ABI Ideal Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL181 compliant.

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
6. Manufacturer: ABI Ideal Tape Division #488 AWF, Avery Dennison Corporation #Specialty Tapes Division Fasson 0800, Compac Corporation #120, Venture Tape #3520 CW or equal.

2.12 FIELD APPLIED DUCTWORK INSULATION JACKETS

A. Field Applied Jackets (For Exterior Applications):

1. Longitudinal seams shall not be located on top of ducts when exposed to outdoor environment. All longitudinal seams shall be located on bottom of ductwork.
2. Stainless Steel Jacket: Type 304 stainless steel, 0.010” minimum (smooth/corrugated) finish.
3. Aluminum Jacket: 0.016” aluminum with factory applied moisture barrier positioned such that the longitudinal overlap provides a watershed.
4. PVC Jacket: Johns Manville #Zeston 300, 30 mil thick, white.
5. Circumferential joints shall be wide enough to provide weather-proofing jacket.
6. Secure jacket with 3/8" or 1/2" stainless steel bands on 12” centers for round ductwork and objects.
7. Secure to rectangular sheet metal with sheet metal screws. Seal screw penetrations with silicone caulk.

2.13 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.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.14 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. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Manufacturer: Johns Manville #Zeston, P.I.C. Plastics #FG Series, Proto Corporation #LoSmoke, Speedline Corporation #SmokeSafe or equal.

D. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
   a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier: 3-mil (0.076 mm) thick polysurlyn.

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier: 3-mil (0.076 mm) thick polysurlyn.

3. Manufacturer: H. B. Fuller Company #Childers Metal Jacketing Systems, ITW Insulation Systems #Aluminum and Stainless Steel Jacketing, RPR Products #Insul-Mate or equal.

E. Self-Adhesive Outdoor Jacket:

1. 60-mil (1.5 mm) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized

bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

2. Manufacturer: Polyguard Products, Inc. #Alumaguard 60 or equal.

2.15 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 4 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts. Manufacturer: H. B. Fuller Company #Childers Chil-Glas No. 5 or equal.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts. Manufacturer: H. B. Fuller Company #Foster 42-24 Mast-A-Fab, Vimasco Corporation #Elastafab 894 or equal.

2.16 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd. (271 g/sq. m). Manufacturer: Alpha Associates, Inc. #84215/9383 or equal.

PART 3 - EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Verify that ductwork has been tested for leakage in accordance with specifications before applying insulation materials. All ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.02 INSTALLATION

A. General:

1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Remove and replace any insulation that has become wet or damaged during the construction process.
3. Continue insulation and vapor barrier at penetrations and duct supports, except where prohibited by code. Instances where this is required include:
    a. Ductwork support angle or struts.
        1) To prevent crushing of low density insulation, provide separator or high density insulation at point of support. A 12 inch wide strip of 6 pcf density, glass mineral wool board or similar manufactured product, across the bottom side of the duct. Vapor barrier to continue unbroken at point of support.

2) As an alternative method, where the duct sits directly on the Unistrut or similar support, install board material on either side of the support to allow duct wrap to be tented over the support, providing a smooth transition over the support and maintaining thickness. Rigid 3 pcf board may be used in this method.

B. Insulation Applied on the Outside/Exterior of the Duct:

1. Provide insulated ductwork conveying air below ambient temperature (below room temperature) with vapor retardant jacket.
2. Seal all vapor retardant jacket seams and penetrations with 3" wide pressure-sensitive vapor barrier tape matching the insulation facing.
3. Where insulation is required, all ductwork, fittings, dampers, elbows, flexible ducts, rigid and flexible connectors, runouts, and devices shall be continuously insulated from fan systems to inlets/outlets to minimize heat transfer into ductwork and prevent condensation on exposed surfaces and as required to comply with applicable mechanical code and energy code.
4. Provide insulated ductwork conveying air above ambient temperature (above room temperature) with or without vapor retardant jacket. Where service access is required, bevel and seal ends of insulation.
5. Continue insulation through walls, sleeves, hangers, and other duct penetrations except where prohibited by code.
6. For ductwork exposed in mechanical equipment rooms below 7' or in finished spaces, finish with jacket material.
7. For interior vapor/moisture conveying duct applications, install glass mineral wool insulation unless specifically indicated otherwise on drawings. Install to meet manufacturer's requirements and as required by local code authorities.
8. Ducts installed exposed outside the building:
    a. For exterior applications where insulation is on the outside of the duct, provide insulation with a weather protection metal jacket or double wall construction.
    b. All exposed to weather exterior metallic ductwork exposed or covered with cladding is to be built with a crown or reverse cross break to shed moisture.

C. Installation of Mineral-Fiber Insulation (Blanket or Rigid Type):

1. Secure weld pins to duct using adhesive recommended for ductwork material. Pins shall be installed on a minimum of three sides of each duct to assure proper support. For overhead ductwork - pins are not required on the top of the ducts. For underfloor ducts - pins are not required on bottom side of ducts. For vertical ducts - pins are not required on surface facing wall. Install pins as follows:
    a. On duct sides with dimensions 18 inches (450 mm) and smaller: Place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) on center.
    b. On duct sides with dimensions larger than 18 inches (450 mm): Place pins 16 inches (400 mm) on center each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing and reinforcement points.
    c. Pins may be omitted from top surface of plenums.
    d. Do not over compress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

2. Install insulation with a continuous unbroken vapor barrier and insulation butted tight at each joint. Create a facing lap for longitudinal seams and end joints with insulation by removing up to 2 inches (50 mm) from one edge as required to allow stapling. Secure laps to adjacent insulation section with 1/2-inch (13 mm) outward-clinching staples, 6 inch (150 mm) on center, maximum. Staples may be omitted when closures are made by machine using heat-sensitive tape. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
3. 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.
4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6 inch (150 mm) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) (maximum) on center.

D. Duct Liner-Insulation Applied on the Interior of the Duct:

1. Adhere insulation to sheet metal with a UL listed adhesive. Adhesive shall be applied to the sheet metal with a minimum coverage of 90%.
2. Secure insulation with mechanical liner fasteners as indicated by SMACNA or manufacturer. Pin length should be as recommended by the liner manufacturer.
3. All exposed edges of the liner must be factory or field coated. Unless factory coated, all transverse edges and longitudinal joints of the duct liner shall be coated. For systems operating at 2,000 fpm or higher, a metal nosing must be installed in all liner facing fan discharge or upstream of the airflow.
4. Repair liner surface penetrations with UL listed adhesive.
5. Duct dimensions indicated on plans are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.
6. Liner shall be folded and compressed into corners of rectangular duct or cut and fitted to assure a lapped compressed joint. Longitudinal joints should not occur in rectangular duct except at corners.
7. Longitudinal joints shall be coated with adhesive.

3.03 DUCTWORK INSULATION SCHEDULES

A. All insulation thicknesses shall meet or exceed latest edition of applicable ASHRAE 90.1, IECC, State Energy Code, Local Energy Code, and State Mechanical Code requirements as noted below. Minimum thermal resistance in range of 4.0 to 4.2 per inch of thickness. Insulation thicknesses are based on glass mineral wool insulation and may be adjusted for equivalent insulation values for materials with superior "K" factors.

B. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

1. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
2. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.
3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

C. All air distribution system ducts and plenums, but not limited to, building cavities, mechanical closets, air handler boxes, and support platforms used as ducts or plenums, shall be installed, sealed, and insulated to meet the requirements of the code. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum level of R-8.

1. Outdoors; or,
2. In a space between the roof and an insulated ceiling; or,
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or,
4. In an unconditioned crawlspace; or,
5. In other unconditioned spaces; or,
6. For buildings subject to compliance with the IECC in any location in Climate Zones 5 through 8 the insulation shall be 3" (R-12) minimum thickness for ductwork exterior to the building envelope.

D. TABLE 1: DUCT WRAP INSULATION SERVICE, THICKNESS, AND MATERIAL TYPE REQUIRED.

TABLE 1: EXTERNAL DUCT WRAP INSULATION			
SYSTEM	R-Value (Minimum)	FINISH/JACKET	INSULATION KEY CODE AND REMARKS
Supply and/or return ducts within building envelope in unconditioned areas, inside shafts and above ceilings.	R-8	FSK or PSK	**DW-A, B, C**
Supply and/or return duct exposed in the atmosphere controlled occupied space.	R-4.2	Black PSK	**DW-C**
Outside air intake ducts within the building envelope.	R-8	FSK or PSK	**DW-A, B**
Exhaust ducts within 10 ft. (3 m) of exterior openings.	R-4.2	FSK or PSK	**DW-A, B**
Adjust insulation thicknesses as required to meet minimum R-Values.			

E. TABLE 2: DUCTWORK RIGID INSULATION AND PLENUM INSULATION SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

TABLE 2: RIGID INSULATION AND PLENUM INSULATION			
SYSTEM	THICKNESS (Minimum)	FINISH/JACKET	INSULATION KEY CODE AND REMARKS
Outside air intake ducts	R-4.2	FSK	**RB-A**. Provide aluminum jacket over exterior installations.
Interior Plenums	R-8	FSK	**RB-A**
Exterior Plenums	R-8 minimum. For any location in colder Climate Zones 5 thru 8 of the IECC increase thickness to R-12.	FSK	**RB-A**
Roof curb walls used for supply or return air that aren't pre-insulated by manufacturer.	R-8	FSK	**RB-A**
Roof surface inside roof curb perimeter and around duct penetrations.	R-8 or greater to match roof insulation value	FSK	**RB-A**
Adjust insulation thicknesses as required to meet minimum R-Values.			

F. TABLE 3: ACOUSTIC DUCT LINER SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

TABLE 3: ACOUSTICAL DUCT LINER			
SYSTEM	THICKNESS (Minimum)	FINISH	INSULATION KEY CODE
Where indicated for rectangular supply or return ductwork installed in conditioned areas.	R-4.2 unless otherwise noted on drawings	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
Where indicated for rectangular supply or return ductwork installed in unconditioned areas without exterior duct insulation.	R-8 unless otherwise noted on drawings	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
Inside supply and return ducts within 20' of Air Handling Unit connections. Applies to the all new ductwork.	R-8	Air stream side mat or other fiber-free facing	**ADL-A, B, C**
VAV terminal unit outlet plenum	R-4.2 unless otherwise noted on drawings	Air stream side shall be fiber-free with resin mat facing, aluminum or mylar liner, or acrylic polymer facing	**ADL-A, B, C**
VAV terminal unit wrap *Contingent on acoustical testing post installation to verify if necessary.	R-4.2 unless otherwise noted on drawings	Terminal box, all sides with seal, with access for controls panel.	**ADL-A, B, C**
Adjust insulation thicknesses as required to meet minimum R-Values.			

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:

1. Piping Insulation:
    a. Piping Insulation.
    b. Insulation Jackets.
    c. Removable Covers.

2. Section includes the following HVAC piping systems:
    a. Refrigerant hot gas and suction piping.

B. Types of mechanical insulation specified in this Section include the following:

1. Flexible elastomeric closed cell foam.
2. Aerocel.
3. Insulation jackets.
4. Removable covers.
5. Insulation accessories.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

1.04 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as "all service jacket" or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.05 INSULATION INDUSTRY DEFINITIONS

A. Third Party Independent Product sustainable certification: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

1. UL GREENGUARD
2. Scientific Certification Systems (SCS)

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.

E. ASJ: All Service Jacket (no outer film).

F. SSL+: Self-Sealing Lap with Advanced Closure System.

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. FHC: Fire Hazard Classification

L. PVC: Polyvinyl Chloride.

M. Bio based Binder Technology: binder systems based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. Biobased Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

N. UL GREENGUARD Gold Certification: Certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

O. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

P. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

Q. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

S. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the "worst in class" materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

T. Underwriter's Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

U. UL Environment Claims Validation (ECV): service and label tests a manufacturer's product and validates that the environmental claims they make in their marketing and packaging materials are factual.

1.06 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
   a. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
   b. C165: Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
   c. C168: Provides standard terminology for thermal insulation.
   d. C177: Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   e. C195: Specification for Mineral Fiber Thermal Insulating Cement.
   f. C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.

g. C302: Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
h. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.
i. C305: Test for Thermal Conductivity of Pipe Insulation.
j. C335: Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
k. C356: Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
l. C411: Test for Hot-Surface Performance of High Temperature Thermal Insulation.
m. C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
n. C449: Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
o. C518: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p. C533:Specification for Calcium Silicate Block and Pipe Thermal Insulation.
q. C534: Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
r. C547: Specification for Mineral Fiber Pipe Insulation.
s. C552: Specification for Cellular Glass Block and Pipe Thermal Insulation.
t. C553: Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
u. C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
v. C612: Specification for Mineral Fiber Block and Board Thermal Insulation.
w. C755: Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.
x. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
y. C916: Standard Specification for Adhesives for Duct Thermal Insulation.
z. C921: Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
aa. C1071: Standard Specification for Thermal and Acoustical Insulation.
bb. C1104: Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
cc. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
dd. C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ee. C1393: Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
ff. C1617-05: Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
gg. E84: Test Method for Surface Burning Characteristics of Building Materials.
hh. E119: Test for Fire Resistance.
ii. G21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
jj. G22: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90: Energy Conservation in New Building Design.

3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255: Test Methods, Surface Burning Characteristics of Building Materials.

B. 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.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method where installed in a return air plenum or in a ventilation intake or mechanical room. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Passes ASTM C1617-05, Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

1.07 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:

1. Pentabrominated diphenyl ether (CAS#32534-81-9).
2. Octabrominated diphenyl ether (CAS#32536-52-0).
3. Decabrominated diphenyl ether (CAS#1163-19-50).

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Comply with requirements in "Part 3, Table 1: Piping Services, Fluid Temperature, and Insulation Type Required" for application of insulating materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall meet UL GREENGUARD certification standards for low-emitting products.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

E. Each insulation material has been provided a descriptive key code, such as PI-A, to simplify the organization and application of materials in following sub-sections.

F. Thickness of insulation is based on meeting or exceeding the minimum requirement of applicable energy code and/or maximum allowable external temperature in relation to adjacent combustible material or other equipment. Exterior surface temperature shall not exceed 140°F at maximum operating capacity except as noted below for generator applications.

G. Acceptable manufacturers include Knauf Insulation, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Aeroflex, Armacell, Reflectix, Pacor or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each product classification.

2.02 PIPE INSULATIONS (IDENTIFIED BY KEY CODE **PI** BELOW AND IN TABLE 1)

A. **PI-B,** Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:

1. Applications: Insulation of piping and fittings with thickness as required by local energy code.

2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84.
3. Service Temperature Range: -297°F to 220°F (-183°C to 105°C).
4. Thermal Conductivity (K-value): 0.28 Btu•in./(hr•ft²•°F) or less, at 75°F (24°C).
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacell #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel or equal.

2.03 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+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.04 JACKETING MATERIALS

A. Field Applied Jackets (For Outdoor Applications):

1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
2. Secure stainless steel or aluminum jackets with 3/8” or 1/2” stainless steel bands on 12” centers and at each joint.
3. PVC Jacket: Not allowed for outdoor applications.
4. Canvas Jacket: Not allowed for outdoor applications.
5. Aluminum Jacket:
    a. Comply with ASTM B209/B209M.
    b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
    c. Thickness: 0.016” thick sheet (minimum).
    d. Finish: Smooth, stucco embossed or corrugated surface.
    e. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.
    f. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
    g. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
    h. Manufacturers: Pabco, Childers, RPR, ITW or equal.

6. Self-Adhesive Aluminum Jacket:
   a. Comply with ASTM D774, C1338, C1371, E96 and D882.
   b. Thickness: 56 mils (minimum).
   c. Multi-ply UV-resistant aluminum foil/polymer laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   d. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.
   e. Weight: 0.3 lbs./sf, minimum.
   f. Service Temperature Range: -15°F to 160°F (-26°C to 71°C).
   g. Manufacturer: Polyguard Products #Alumaguard or equal.

7. Stainless Steel Jacket:
   a. Comply with ASTM A240 and A666.
   b. Stainless steel alloy T-304 or T-316. T-316 shall be used in corrosive environments including close proximity to coast.
   c. Thickness: 0.016" thick sheet (minimum).
   d. Dull Finish: Smooth, stucco embossed or corrugated surface.
   a. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
   g. Manufacturers: Pabco, Childers, RPR, ITW or equal.

B. Removable Covers:

1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.
   a. Pre-molded insulation covers:
      1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
      3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.
   b. Removable cloth insulating blankets:
      1) Service Operating Temperature: 0-350°F.
      2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
      3) Liner Reinforcement: stainless steel mesh cloth.
      4) Insulation: Fiberglass matt or Pacor #Aerogel, 2" thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
      5) Fastening: 2" Nomex Velcro or 1" straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
      6) Thread: Kevlar/stainless steel thread.
      7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.
      8) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, Alpha or equal.

2.05 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. Calcium Silicate Adhesive:

1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 1200°F (10 to 649°C).
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-97, Johns Manville #CalBond Gold, Marathon Industries #290, Foster Brand #81-27, Mon-Eco Industries #22-30, Vimasco Corporation #760 or equal.

C. Cellular-Glass Adhesive:

1. Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200°F (minus 73 to plus 93°C).
2. 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).
3. Manufacturers: Foster Brand #81-84 or equal.

D. Phenolic and Polyisocyanurate Adhesive:

1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
2. 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).
3. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33 or equal.

E. Flexible Elastomeric and Polyolefin Adhesive:

1. Comply with MIL-A-24179A, Type II, Class I.
2. 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).
3. Manufacturers: Armaflex #520 Adhesive, Foster Brand #85-75, K-Flex USA #R-373, Aeroflex USA, Aeroseal, Armacell, or equal.

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

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Childers Brand #CP-127, Eagle Bridges - Marathon Industries #225, Foster Brand #85-60/85-70, Mon-Eco Industries, Inc.#22-25 or equal.

G. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Childers Brand #CP-82, Eagle Bridges - Marathon Industries #225, Foster Brand #85-50, Mon-Eco Industries, Inc.#22-25 or equal.

H. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Dow Corning Corporation #739, Dow Silicone, Johns Manville #Zeston Perma-Weld, CEEL-TITE #Solvent Welding Adhesive, P.I.C. Plastics, Inc. #Welding Adhesive, Speedline Corporation #Polyco VP Adhesive or equal.

2.06 MASTICS

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

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 for indoor use.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Vapor Safe Coating: VOC 33 g/l, less water and exempt solvents.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.
6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749 or equal.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.
5. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96 or equal.

D. Breather Mastic: Water based for indoor and outdoor use.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.
5. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5 or equal.

2.07 LAGGING ADHESIVES

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.

1. Comply with MIL-A-3316C, Class I, Grade.
2. 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).
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
5. Color: White.
6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714 or equal.

2.08 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate.
   a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pittseal 444 or equal.

2. Joint Sealants for Polystyrene.
   a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05 or equal.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
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).

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: Aluminum.
5. 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).
6. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05 or equal.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.

5. 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).
6. Manufacturers: Childers Brand #CP-76 or equal.

2.09 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
7. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ or equal.

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

1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

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

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
6. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW or equal.

2.10 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
3. Manufacturers: ITW Insulation Systems, Gerrard Strapping and Seals, RPR Products, Inc., Insul-Mate Strapping, Seals, and Springs or equal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   a. Manufacturers: AGM Industries #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   a. Manufacturers: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   d. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners, Inc.#Spindle or equal.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
d. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners, Inc.#Nylon Insulation Hangers or equal.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12 gauge, 0.106-inch - (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
   d. Manufacturers: AGM Industries, Inc. #Tactoo Self-Adhering Insul-Hangers, GEMCO #Peel & Press, Midwest Fasteners #Self Stick or equal.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless-steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
   b. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Manufacturers: GEMCO, Midwest Fasteners, Inc or equal.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

1. Manufacturers: C & F Wire or equal.

PART 3 - EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping and ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.02 INSTALLATION

A. General:

1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Cold or chilled water systems shall not be operated in normal mode until all piping has been fully insulated with continuous vapor and no exposed joints or seams.
3. Remove and replace any insulation that has become wet or damaged during the construction process.
4. Pipe fittings, valves, pipe flanges, pumps, strainers, gauge fittings, etc., shall be insulated to the same insulation thickness as adjoining piping and as required by local energy code.
5. All support points, joints and fittings shall be insulated for continuous insulation coverage with no gaps or voids or exposed cold surfaces are allowed in the system. Continuous insulation implies that insulation shall meet or exceed the minimum thickness throughout the insulated system with no reduction in thickness at any location.
6. Pipes that are to be insulated, including chilled and heating water, shall not be in direct contact with support elements such as clevis or trapeze or saddle or shield devices. This may not apply at seismic restraint locations depending on type of restraint system used. Pipes must use appropriate insulating options at support locations to allow the insulation and vapor barrier to be sealed continuously through each support with insulation joints located a minimum of 6” from each support location to allow for commissioning confirmation.
7. At each seismic restraint locations and riser clamps, the support system shall be fully encapsulated with insulation and vapor barrier, and all gaps/joints sealed airtight. Insulation on support elements, including threaded rods, cables and metal bracing, shall extend a minimum of 6” beyond the insulation jacket, or additional as required, to prevent condensation and uncontrolled heat transfer.

B. Piping Insulation:

1. Locate insulation and cover seams in least visible locations unless otherwise specified.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Provide vapor retardant jackets with self-sealing laps on insulated cold pipes conveying fluids below ambient temperature. Insulate complete system. Staples used on pipes conveying fluids below ambient temperatures (cold systems) must be covered with approved mastic.
4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self-sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
5. Provide insert between support shield and piping on piping 1-1/2” diameter and larger. Fabricate insert using hydrous calcium silicate or other heavy density insulating material suitable for temperature and required insulation thickness. Insulation inserts shall not be less than the following lengths:
   a. 1-1/2" to 2-1/2" pipe size: 10" or longer.
   b. 3" to 6" pipe size:12" or longer.
   c. 8" to 10" pipe size: 16" or longer.
   d. 12" pipe size and larger: 22" or longer.

6. For smaller pipe sizes, less than 1-1/2” diameter, provide metal or pre-manufactured plastic insulation shield to support the insulated pipe through the support point at the hanger or saddle. Pipe shield shall be a minimum of 6” long to distribute the weight of

the insulated pipe without crushing or damaging the insulation. Pipe shield shall be located outside of the metal insulation jacket where applicable.

7. Use of metal saddles is acceptable as specified in Section 230500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
8. Use of pipe hangers designed with an insulation coupling may be acceptable in lieu of saddles and other devices.
9. Where pumps, valves (manual and control types), strainers, etc., with insulation require periodic opening for maintenance, repair or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
    a. Cold Systems: Provide elastomeric foam for pumps and strainers.
    b. Hot Systems: Provide removable blanket covers on valves, pumps, and strainers.

10. For exterior applications:
    a. Apply weather-resistant protective finish to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping.
    b. All lateral and longitudinal insulation joints to be sealed with low VOC, UV inhibitive adhesive.
    c. Provide weather protection jacket over insulation. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. PVC or plastic jackets are not allowed exterior to the building. Jacket seams shall be located on bottom side of horizontal piping. All lateral jacket joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal jacket joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).

11. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.
12. Jacket Locations for Pipe, Valve and Fittings. Provide protective insulation jackets for the following locations where not defined elsewhere in the specifications for piping systems:

Insulation Jacket Location	Jacket Material
Outdoors: Exposed to weather.	Aluminum or stainless steel with white coating for low emissivity.
Outdoors: Exposed in covered outdoor areas such as garages or under canopies.	Aluminum or stainless steel.
Outdoors: Located in vaults or accessible concrete trenches.	Aluminum or stainless steel.

3.03 PIPING INSULATION SCHEDULE

A. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED.

1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2" (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior "K" factors. Refer to "PART 2-PRODUCTS" for characteristics of each insulation material listed below.

PIPE INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
PI-A	Preformed Flexible Mineral Wool or Fiberglass.
PI-B	Preformed Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene.
PI-C	Preformed Rigid Closed-Cell Phenolic Foam.
PI-D	Preformed Rigid Closed-Cell Polyisocyanurate Foam. Limited to non-plenum rated applications.
PI-E	Rigid Preformed Hydrous Calcium Silicate.
PI-F	Rigid Closed-Cell Cellular Glass.
PI-G	Flexible Low Temperature Aerogel.
PI-H	Flexible High Temperature Aerogel.
PI-I	Flexible Extreme High Temperature Aerogel.

TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Cooling Coil condensate piping and traps located outdoors	**N/A**	Not required.
Refrigerant suction piping.	**PI-B**	Provide 3/4" (minimum) thickness insulation or increased thickness as required by State Energy Code. See Table 2 below.
Refrigerant liquid and hot-gas piping.	**PI-B**	Provide 3/4" (minimum) insulation for all warm/hot piping in close proximity to human contact and where located in enclosed ceiling, shaft or chase spaces.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 – GENERAL

1.01 SUMMARY

A. Section includes Commissioning activities required for work of Division 23 Sections including but not limited to construction checks, equipment start-up, functional testing, and operator training.

1. Comply with Section 01 91 13 – General Commissioning Requirements for Commissioning activities for Division 23 work.

1.02 SEQUENCING

A. Provide written notification to Commissioning Provider (CxP) in advance of significant project dates as directed and as listed below.

1. Two weeks prior to start-up of air handling units, air-conditioning units, exhaust fans, boiler and pumps
2. Four weeks prior to installation of lay-in ceiling tiles or other partial concealment of equipment to be commissioned
3. Four weeks prior to any system ready for balancing

1.03 SUBMITTALS

A. Provide control system custom software, hardware, and technical manuals as necessary for development of Commissioning activities. Control system submittals include but are not limited to operating sequences, point database, workstation remote access, on-site custom programming/editing software, and programming and operations manual as necessary for development of Commissioning activities. Submit a minimum of 12 weeks prior to equipment start-up.

B. Provide submittals of systems being commissioned to Owner's Authorized Representative as required by Section 01 91 13.

C. Provide electronic copies (or hard copies where appropriate) of control system final configuration parameters, programs, databases, files, and electrical data as necessary to reconfigure and/or replace control components upon device failure.

D. Testing, Adjusting, and Balancing (TAB) Pre-balancing Submittal: Provide electronic submittal directly following approval of the HVAC control submittal. The TAB pre-submittal shall include the following:

1. Preliminary TAB report including report documentation forms with design data and existing equipment data listed.
2. Review Contract Documents and provide list of provisions that are not included but necessary to complete work such as balancing dampers, valves, flow measuring stations, test plugs, access doors, etc.

a. Provide a description of any conditions that are unclear, contradictory, or otherwise may prevent the specified system from achieving design performance.

3. Summary of BAS system calibration measurements and tests required to establish setpoint or control parameters such as duct static pressure setpoints, airflow and/or fan speed offsets, pump differential pressure etc.
4. Summary of minimum outside air ventilation measurements, adjustments, and control devices required to establish specified control sequences (i.e., damper positions, fan speeds, airflow station etc.)

PART 2 - PRODUCTS

2.01 MATERIALS

A. Provide all necessary control hardware, software, and temporary licenses to enable Commissioning Provider to conduct activities and to fully access any electronic control systems furnished for this project. Commissioning Provider's laptop computer may be used for access if software and hardware systems provided are compatible with existing computer configuration, otherwise furnish laptop computer where required for duration of project.

B. Provide minimum of two HVAC control operator interface sites for both on-site and remote access as described below:

1. Commissioning Provider Access Functions: Review and modification of control programming, monitoring of control system operations, review and modification of software database, setup, and monitoring trend data in tabular and graphical formats.
2. Remote Access: Remote access using Internet and shall include all functions described above.
3. Provide credentials for Commissioning Provider. Security access level shall be suitable to perform necessary commissioning functions.
4. Provide labor required to install hardware and software on personal computers at Commissioning Provider's office. Software will be manufacturer's most recent version and will be compatible with the CxP's personal computers. Provide Commissioning Provider with two hours training after fully functional remote access is established.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Manufacturer's Representative to execute Construction Checklists and perform operational training as specified in Division 23 including the following systems:

1. Boiler
2. Rooftop air handling units

3.02 CONSTRUCTION CHECKLISTS

A. Contractor shall execute as required by Section 01 91 13. Construction Checklists for each system commissioned will be prepared by Commissioning Provider during construction.

3.03 CONTROL VERIFICATION REPORTS

A. Building Automation System: BAS control contractor shall perform verification of the function and performance of control hardware and software. Execute verification report demonstrating proper system installation and operation. Verification report shall include the following:

1. Network Communication: Verify that all network devices properly communicate on network. Verify communication speed and reliability is acceptable.
2. Input and Output Verification:
    a. Verify that all input and output points are indicating properly. Verification tests shall be "end-to-end," meaning field measurement to workstation graphic display value.
    b. Calibrate all analog inputs. Acceptance accuracy shall be as specified for product accuracy. Repair or replace all devices that do not conform to specified accuracy.
    c. Operate all analog outputs from 0% to 100% of operating range. Verify that controlled device operates over the entire output range and that maximum and minimum operating conditions are achieved.
    d. Valves and dampers shall close fully and provide tight shutoff. Leakage rates shall not exceed specified values.
    e. Verify that all digital outputs operate controlled devices.

3. Sequence of Operation Verification: Systematically verify automatic control sequence of operation functions in field after installation is complete. Verification shall include:

    a. Time scheduling.
    b. Operating modes.
    c. Tune and adjust control loops and control sequences to optimize efficiency and performance. Control loops shall be stable and maintain desired setpoints.

4. Trending: Confirm trending utilities storage of operating data as required to verify operation and performance of control modes, sequence, and loops. Meet with Owner and CxP to review configuration, parameter interval, and duration prior to trend setup.
5. Operator Interface: Review function of operator interface. Confirm that graphic operator interface accurately depicts as-constructed system configuration and that all required content is displayed and functions as intended.
6. Alarms: Confirm alarm utilities are configured as required, alarm conditions are displaying in alarm logs and on graphic displays, and provide annunciation and reporting as required. Meet with Owner and CxP to review configuration parameters prior to alarm utility setup.
7. Coordination: Assist balancing contractor with development of control setpoints and parameters as specifically indicated or otherwise required to provide Sequence of Operation. Setpoints would include but would not be limited to actuator positions required to provide minimum ventilation rates, supply air pressure setpoints for variable air volume air distribution systems, and terminal unit calibration parameters.
8. Controls Verification Report: After system operation is completely verified, provide written certification to Owner that systems have been fully tested, are operating according to specifications, and ready for functional testing. Include documentation to the Commissioning Provider detailing verification results. Report shall include:

a. Updated control construction drawings and equipment data that incorporates all changes made during construction.
b. Printed as-built control code.
c. Printed point data base.
d. Input/Output Verification Log: Submit point verification log including point identification, control system readout value, verification measurement, and required calibration offset where applied.
e. Sequence of Operation Verification: Submit verification test report listing complete text of control sequence and test results. Verify all specified control sequences.
f. Trend Logs: Submit printed trend reports for the following:

    1) Time schedules. Seven-day log demonstrating that equipment operates according to programmed time schedules.
    2) Automatic control sequences. Trends shall be set-up as follows:

        a) Analog Control: Points that modulate over time shall be sampled at appropriate intervals and durations to demonstrate proper operating sequences. For example, a discharge temperature control loop would require trending during the morning warm-up mode and normal daytime operation mode. Each trend shall include all measured variables, control output signal, actual output signal, and controlled variable.
        b) Digital Control: Dual-state control or monitoring points shall be recorded as COV (+) or change of value meaning that the changed parameter only needs to be recorded after the value changes from its previous state. A minimum of one week of samples shall be provided to properly demonstrate equipment cycles, modes, and schedules.

g. Include trend graphs as described below:
    1) Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
    2) Indicate engineering units of the y-axis values; e.g., degrees F., inches w.g., Btu/lb, percent wide open, etc.
    3) The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
    4) All points trended for one HVAC subsystem; e.g., air handling unit, chilled water system, etc. shall be trended during the same trend period.
    5) Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

h. List of incomplete work.

9. Demonstration: Demonstrate operation of control system to Engineer, Commissioning Provider, and Owner including:

    a. Menu functions.
    b. Point overrides.
    c. Control loop response after point modification.
    d. Alarm response time.

3.04 FUNCTIONAL TESTING

A. Contractor shall assist Commissioning Provider with functional testing as required by Section 01 91 13. Functional Test Plans for each system being commissioned will be prepared by Commissioning Provider during construction and will generally include a rigorous verification of instrument calibration, equipment performance, packaged equipment control system operations, automatic control sequence of operations, fire and life safety sequences, and operator interface functions. Commissioning Provider will supervise and document functional testing. Contractor shall provide qualified technicians to assist Commissioning Provider during on-site testing and perform the following functions.

1. Operate equipment and systems as necessary to conduct testing.
2. Manipulate control parameters to simulate test conditions as detailed in Functional Test Plans.
3. Access control programming and database as required to verify control configuration or to correct observed deficiencies.
4. Create graphic displays and/or trend report as required to document test results.
5. Provide proprietary hardware and software as needed to interface with manufacturer's packaged control systems.

B. Labor required for retesting due to failure of equipment, or systems not performing in accordance with Contract Documents shall be provided at no additional cost to Owner.

3.05 OPERATIONS AND MAINTENANCE TRAINING

A. The Contractor shall provide operation and maintenance instruction to Owner's personnel as required by Division 01 and 23.

3.06 SCHEDULE OF SYSTEMS BEING COMMISSIONED

A. Commission systems and equipment listed below, including associated equipment, piping, ductwork, and control systems.

B. HVAC Systems: Air handling units, terminal units, exhaust fans, boiler and building automation controls

END OF SECTION 230800

SECTION 230902 - VARIABLE FREQUENCY DRIVES (VFD)

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. Furnish complete and operational VFD systems as shown on the plans. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Variable frequency drives (VFDs), with or without bypass, as scheduled on drawings.
2. Controls and control connections.
3. Electrical power connections.

1.03 RELATED WORK IN OTHER SECTIONS

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230900: Building Automation System (BAS) Controls

D. Section 232123: Hydronic Pumps

E. Section 237312: Custom Factory Air Handling Units

F. Division 26: Coordination of interface items between the Mechanical equipment and controls and the Electrical Work specified in Division 26.

1.04 DEFINITIONS

A. THD: Total Harmonic Distortion in %. RMS value of harmonic currents expressed as a percentage of fundamental current occurring at the fundamental frequency (60 Hz). This equals the square root of the sum of the squares of the amplitudes of the 2nd through the 50th harmonic currents, divided by the amplitude of the 1st harmonic. Used for both voltage (THDv) and current distortion (THDi).

B. TDD: Total Demand Distortion in %. This equals the square root of the sum of the squares of the amplitudes of the 2nd through the 50th harmonic currents, divided by the amplitude of the maximum demand current of the facility. This is used by IEEE 519 to determine the harmonic

current distortion that a facility presents to the utility. TDD is not the current distortion of any individual device.

C. RMS

1.05 QUALITY ASSURANCE

A. Supplier of VFD shall be solely responsible for assuring that the VFD shall work properly with the motor(s) being controlled. VFD supplier shall provide all materials and labor required to replace motors, bearing, shafts, etc. that may be incompatible with VFD or become damaged by VFD at no additional cost to the owner. VFD supplier shall reimburse Architect and Engineer at their standard hourly rates for their involvement in resolving failures due to their VFDs.

B. Manufacturer shall have a minimum of 15 years of experience building similar equipment for controlling the speed for induction motors and at least one hundred successful installations with a variety of VFD sizes and applications.

C. To reduce the known problem of bearing failures by "fluting" the VFD switching rates shall be 6-8 KHz wherever possible. Manufactured VFDs at switching rates of 12-15 KHz shall be accompanied by an additional extended warranty to cover bearings and motors to a period of ten (10) years. Shaft grounding is not required for EC motors with integrated speed controller. Acceptable manufacturers include Shaft Grounding Systems (www.shaft-grounding-systems.com) or Aegis Shaft Grounding Ring (www.est-aegis.com).

D. To ensure quality and minimize infantile failures at the job site, the VFD shall be burned in at the factory at an ambient of 104°F minimum for at least 8 hours. The VFD shall be operating a dynamometer and the load speed shall be cycled during the test. All optional and special features shall be functionally tested at the factory for proper operation.

E. Standards and Guidelines: Provide VFDs conforming to the requirements of the latest addition of the following:

1. UL 508: The UL Safety Standard for Industrial Control Equipment. All VFD equipment provided under this section must be labeled as UL 508 approved.
2. ANSI/IEEE 518: Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources.
3. ANSI/IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems. This addresses the current distortion of a complete facility and not current distortion of individual pieces of equipment within the facility.
4. International Standards Organization (ISO) certified 9001.
5. International Building Code (IBC) seismic requirement referencing ASC 7 and ICC AC-156.
6. International Electrotechnical Commission 60721-3c1, 2, & 3 Conformal coating
7. NEC 430.120, Adjustable-Speed Drive Systems.
8. NEMA ICS 7.0, Application Guide for AC Adjustable Speed Drives.
9. AHJ approval or proof of special seismic certification for structures requiring it.
10. RoHS (Restriction of Hazardous Substances) certified.
11. SEMI F47-0706 for voltage sag immunity

F. Performance Standards: VFDs shall be tested and listed for drive system efficiency, motor insulation and power line harmonics conforming to the requirements of one, or more, of the latest addition of the following:

1. AHRI 1210/1211: Performance Rating of Variable Frequency Drives.
2. IEC 61800: Adjustable Speed Electrical Power Drive Systems.

1.06 QUALIFICATIONS

1. VFDs and options shall be UL 508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for external input fuses.
2. The entire VFD assembly, including the bypass (as scheduled on drawings), shall be seismically certified and labeled as such in accordance with the International Building Code (IBC) and local amendments:
   a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
   b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156
   c. AHJ approval if needed.
3. Base VFD shall have CE Mark conforming to European Union Electromagnetic Compatibility directive, requiring VFD meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the drive in compliance with the First Environment levels.
4. VFD Enclosure to be UL rated: 1,12, 3R, 3RX, 4 or 4X as needed. Cabinets correctly sized for airflow and heat dissipation of drive with interlocked handle. Outdoor 3R enclosures include thermostatically controlled vent fans and heater. 4X shall be stainless steel cabinet with temperature controlled air-conditioned air isolated from outside air in the VFD cabinet. Self-certified UL enclosures not accepted.
5. Factory authorized start up and owner training should be provided locally upon request. A toll free 24/365 technical support line connected to factory support personnel located in the US shall be available
6. VFDs and bypasses shall be considered as an "end device" and not specifically listed as UL 864 UUKL compliant. However, VFDs shall be provided with control and override capabilities as required for smoke control.

1.07 SUBMITTALS

A. Prior to construction submit for approval the following materials:

1. VFD supplier shall provide reference list showing at least ten years of prior manufacturing experience in production of VFDs and a list of at least twenty successful installations with a variety of VFD sizes and applications.
2. Manufacturer's data, installation instructions, and maintenance and operational instructions for variable frequency drives. Indicate electrical service and special requirements. Include manufacturer's descriptive literature, repair data, and parts listing.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units. Remove damaged equipment from site.

1.09 WARRANTY

A. Provide minimum two-year (24 months) warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB ACH580 (1 to 350 hp), ABB ACH880 (Ultra Low Harmonic Drive), ABB ACC55 (Micro Drive 0.25 to 3 hp). Or, equal by Danfoss, Allen-Bradley, Emerson, Schneider Electric (Square D), Toshiba, or Yaskawa.

2.02 GENERAL

A. Furnish a complete VFD as scheduled on the plans. Refer to plans for locations of variable speed controllers. Each fan or pump motor shall have a dedicated VFD unit. All standard and optional features shall be included within the VFD enclosure unless otherwise specified. The VFD enclosure shall be provided to match the environment requirements where the VFD will be mounted and operated. Provide NEMA/UL rated enclosure as required for environment.

B. The adjustable frequency controller shall convert three-phase, 60 Hz utility power to adjustable voltage and frequency, three-phase, AC power for stepless motor speed control from 10% to 100% of the motor's 60 Hz speed.

C. The VFD shall provide full rated output from a line of ±10% of nominal voltage. The VFD shall continue to operate without faulting from a line of +30% to -35% of nominal voltage. Overload rating of VFD shall be 110% of normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. VFDs shall be capable of continuous full load operation in the following environmental conditions:

1. -15 to 40° C (5 to 104°F) ambient temperature. Operation to 50° C (122°F) shall be allowed with a 10% reduction from VFD full load current.
2. Altitude 0 to 3300 feet above sea level. Operation to 6600 feet shall be allowed with a 10% reduction from VFD full load current.
3. Humidity less than 95%, non-condensing.

D. The VFD shall include a converter and an inverter section. The converter section shall convert fixed frequency and voltage AC utility power to a DC voltage. Drive shall utilize a single surface mount micro-processor.

E. The VFD shall be of the pulse width modulation (PWM) type. VFDs shall be provided with an advanced flux vector frequency control to limit noise at drive and motor.

F. Drive manufacturer or sales representative shall evaluate electrical system of the project. Any additional protective equipment such as line filters, reactors or input isolation transformers required to prevent interference from drive with other electrical equipment in the building shall be included as part of the bid. No additional expense shall be incurred by Owner for provision or installation of these devices if required for electrical system operation after drive has been purchased. Units shall include factory mounted input line reactors.

G. The VFD maximum output current rating shall be 110% of the motor nameplate full load current. VFD shall be able to start into a rotating load in either direction without trip.

H. The VFD and options shall be tested to ASNI/EIA Standard 508 and listed by a nationally recognized testing agency such as UL or ETL.

I. The VFD and options shall comply with the applicable requirements of the latest standards of ANSI, IEEE, and the National Electrical Code.

J. Power line noise shall be limited to a voltage distortion factor and line notch depth as defined in ANSI/IEEE Standard 519.

K. The drive efficiency shall be 97% (minimum) and have a fundamental power factor of 0.98 at all speeds.

2.03 BASIC FEATURES

A. The VFD shall be housed in a NEMA enclosure appropriate to the mounting location.

1. NEMA 12 enclosure shall be used indoors in dusty locations, plenum mechanical rooms, penthouses, or air stream mounting.
2. NEMA 3R is required for all outdoor locations exposed to falling rain, snow or ice or to indoor locations subject to falling water.
3. If NEMA 1 enclosure is suitable it shall be vented through cabinet and equipped with an integral cooling fan with thermostat control and arranged so that units can be mounted back to back on a frame and/or side to side on a wall. Venting fans shall be supplied in enclosure if required. If a different NEMA enclosure is indicated the enclosure shall provide means of maintaining the drive at temperature acceptable to the drive manufacturer in exterior ambient temperatures. Enclosure shall be complete with no requirements for low voltage wiring. Factory mounted main circuit breaker disconnect shall be included.

B. All circuit boards shall be coated to protect against corrosion. Control boards shall be conformal coated to at least IEC 60721-3c2.

C. All VFDs shall have the same HMI/keypad, with backlit digital display, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs. It shall incorporate "Bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. HMI/keypad shall include password protection against parameter changes.

D. The HMI/keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting. The display shall be in complete English words for programming and fault diagnostics (alphanumeric codes only are not acceptable.)

E. The HMI/keypad shall utilize pre-programmed application macros or templates specifically designed to facilitate start-up. The Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user savable programs to allow the user to save custom settings.

F. HMI/keypad operating values shall be capable of being displayed in engineering units for sub-metering purposes [i.e. GPH, KW, Motor Amps, Frequency, Speed, Torque, etc.]. A minimum of three operating values shall be displayed at all times.

G. VFD shall have the option to support Bluetooth Advanced Control Panel and Apps. The Bluetooth control panel shall be FCC and QSL (Qualified Design Listing) certified.

H. VFD shall include built in coordinated AC transient surge protection system consisting of four MOVs (phase to phase & phase to ground), capacitor clamp, 1600 PIV Diode Bridge and internal chokes.

I. VFDs shall have 5% impedance AC reactors or internal dual 5% DC chokes to reduce harmonics to the power line and as protection from AC line transients. VFD's with only one DC choke shall have OEM add AC UL 508 listed and approved Chokes or line reactors. Maximum allowable total demand distortion shall not exceed 5% and the total harmonic distortion shall be less than 3%. VFDs using thin wall, small DC bus or metallic type capacitors must add active harmonic filters to prevent high frequency harmonics from corrupting the electrical system.

J. VFD shall automatically mitigate harmonics throughout the effective load range using Swinging chokes or other devices designed to lower harmonics when VFD is at partial loads.

K. VFDs shall include Ferrite Core EMI/RFI/Common mode filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2).

L. The input current rating of the VFD shall not be greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.122.

M. VFDs shall be able to have a distance from the VFD to the motor of at least 250 feet at the maximum carrier frequency, or provide a DV/DT filter in addition to each VFD as needed to protect the motors.

N. VFD shall have its own standardized control board that is the same for all drive sizes, with all communications and I/O terminals on it, and standard BAS communications protocols to include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet MS/TP. All diagnostic warning and fault information shall be transmittable over serial communications. With Remote fault reset if programmed. Options available for: Ethernet IP, BACnet IP, ControlNet, DeviceNet, EtherCAT, Lonworks, ModBus TCP and Profibus. All protocols shall be "certified" by the governing authority. VFD shall have ability to provide feedback to the BAS for kWh, speed of drive, torque load, load curve status, current proof using built-in current sensors, alarm and faults indication, motor temperatures, and other input and output status conditions.

O. Two (2) programmable analog inputs shall accept 0-10VDC or 4-20 ma signals.

P. Two (2) programmable analog outputs 0-20ma or 4-20 ma signals. Outputs proportionally programmable for: Motor Current, Power, Speed, Torque, (kW) and other data.

Q. Minimum of six (6) programmable digital inputs for interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

R. Minimum of three (3) programmable, Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. Rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts.

S. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others.

T. The VFD shall have Pass thru I/O- to allow the BAS to monitor and control the VFD/ bypass or its analog and digital outputs via communications. This control shall be independent of any VFD function and may be used to control or monitor any other device.

U. The VFD shall include multiple "two zone" PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20mA, 0-10V, and/or communications). The two zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals. All of the VFD PID controllers shall include the ability for "two zone" control. The PID set points shall be adjustable from the VFD keypad, analog inputs, or over the communications bus.

V. The VFD shall have cooling fans that are designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required, based on the temperature and run command to the drive. VFD protection shall be based on thermal sensing and not cooling fan operation.

W. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with a 10-year minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. VFD programming shall be held in non-volatile memory and is not dependent on battery power.

X. Drive options shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

Y. VFD shall include option for nonpowered programming via Laptop and adapter.

Z. VFD shall include option for a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameters. Bluetooth connectivity shall include two pairing modes-always discoverable with a fixed passcode and manual discovery with a unique generated passcode every pairing.

2.04 PROGRAMMABLE ADJUSTMENTS

A. Three (3) programmable critical frequency lockout ranges (aka Skip or resonant) to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.

B. The VFD shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates.

C. Two independent adjustable acceleration and deceleration ramp times, adjustable from 1 to 1800 seconds, initial settings shall be 60 seconds set by manufacturer.

D. VFD shall include a motor flux optimization and noise smoothing circuits that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise.

E. VFD shall provide built-in current sensor with programmable loss-of-load (broken belt / broken coupling) option to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the BAS.

F. VFD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

G. VFD to have two PID controls built in for VFD or other uses. PID controllers have ability for "two zone" control. PID set points adjustable from the VFD keypad, analog inputs or BAS

H. If the input reference is lost, the VFD shall be programmable to: (1) stop and display a fault, (2) run at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) go to a backup control system wired to the VFD. As well as cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, Form-C relay output and / or over the communication bus.

I. VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time and time between attempts shall be programmable. VFD shall be initially set to perform at least five (5) restarts after a power outage, drive fault or external fault before requiring manual reset. After ten minutes of runtime, the restart attempts return to zero. The VFD shall display a countdown timer when auto restart is being attempted, or incorporate programming to select number of restarts, number of faults per time period, and time between restarts.

J. VFD shall be capable of starting into a coasting load (flying start or forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage.

K. VFD shall include a fireman's override input. Upon receipt of a contact closure from the fire / smoke control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation, without the need to cycle the normal digital input run command.

L. Micro Drive VFDs shall have the following features and programmability:

1. Each Micro Drive shall have a HMI/keypad with Hand-Off-Auto modes, manual speed control, fault reset on it and ability to program the VFD for all functions. Ability to save VFD program preferred.
2. Each Micro Drive shall have the ability to run on single phase of power when derated 50%.
3. Each Micro Drive shall have at least one analog input and digital inputs and outputs built in when needed.
4. Each Micro Drive when needed shall have BAS communications protocols to include: ModBus RTU; Johnson Controls N2, and BACnet MS/TP are preferred.

2.05 PROTECTIVE FEATURES

A. A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

B. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

C. Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

D. Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

E. Protect from over voltage. The VFD shall continue to operate without faulting with a momentary input voltage as high as 130% of the nominal voltage.

F. The VFD shall incorporate a programmable motor preheat feature to keep the motor warm and prevent condensation build up in the motor when it is stopped in a damp environment by providing the motor stator with a controlled level of current.

G. VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.

H. VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.

I. VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.

J. Selectable over-voltage control shall be provided to protect the drive from power regenerated by the motor while maintaining control of the driven load.

K. VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.

L. If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

M. In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.

N. The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

O. The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.

P. When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take appropriate protective action when one of the above situations is detected.

2.06 BYPASS (WHEN SCHEDULED)

A. Bypasses shall be a complete assembly UL 508 listed, furnished and mounted by the OEM as defined on the VFD schedule. All bypasses shall have a service Disconnect switch with two (2) contactor operation. They shall also have a UL rating of SCCR of 100,000 Amps.

1. Factory wired and tested system with door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting Drive Isolation input fuses. UL Listed motor electronic overload protection Class 10, 20, or 30 (programmable) shall be included in both drive and bypass modes.
2. The drive and bypass package shall be Seismic certified and labeled to IBC 2012:
3. Rating of 1.5 is required and based upon actual shake table test defined by ICC AC-156.
4. AHJ preapproval as needed.
5. Bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair/replacement. Bypass can be controlled by inputs, locally or by communications.
6. Bypass designs must allow qualified person to work on or remove bypassed VFD for service and allow bypass to continue to run system. Only approved per NEC 430.103 service disconnect switch with two (2) contactors should be used. Three contactor or "isolation contactors" are not an acceptable alternative to fuses and are not an NEC recognized disconnecting device for LOTO.
7. Bypass shall have its own standardized control board that is the same for all drive sizes, with all communications and I/O terminals on it. The keypad and two line (minimum), 20 character LCD display to control or program unit, read status and reset faults. Bypass shall have preset macros with user programmable options. As well as let user select whether the system shall automatically transfer from drive to bypass mode on the

following drive fault conditions: Over current, Over voltage, Under voltage or Loss of analog input.

8. Bypass shall have its own built in communications protocols that include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN(P1); and BACnet MS/TP. All bypass diagnostic warning and fault information shall be transmitted over the communications. With Remote bypass fault reset if programmed. Options available for Lonworks, ControlNet and DeviceNet.
9. Bypass shall have Pass-Through analog and digital Inputs and Outputs that are capable of being monitored and/or controlled via serial communications for the drive or other devices.
10. Bypass shall have a proof of flow and broken belt adjustable motor current sensing circuit for bypass and VFD modes, condition shall be indicated on keypad display or over the BAS.
11. Bypass shall have six 24VDC digital inputs on its own separate terminal strip and incorporate an internally sourced 24VDC 250 mA power supply for use by itself or others to power external devices and not require an external control power source.
12. The bypass shall include a supervisory control mode. In bypass mode it shall monitor the value of the VFD's analog input (feedback). This feedback is used to control the bypass contactor on and off to maintain hysteresis control over applications such as cooling towers and booster pumps.
13. The user shall be able to select text to be displayed on the keypad when an external safety opens. Such as "FireStat", "FreezStat", "Over pressure" and "Low suction". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.
14. Bypass shall meet requirements of SEMI F47-0706 for voltage sag immunity and maintain positive contactor control with a +30%, -35% tolerance of nominal voltage. This feature is designed to avoid contactor coil failure during brown out/low line conditions and allow for single-phase operation in VFD mode. Designs that will not allow single-phase operation in VFD mode and meet F47 are not acceptable.
15. Single phase Motor protection bypass must be able to detect a single phase condition IF VFD is running and prevent transfer as well as detect single phase power condition if it occurs while running or trying to start in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication locally and to BAS if programmed. Bypass systems not incorporating single-phase protection in bypass mode are not acceptable.
16. Earth or ground fault motor protection bypass system must be able to detect earth or ground fault if VFD is running and prevent transfer as well as detect if a ground fault condition occurs while running or trying to start in bypass, disengage the motor in a controlled fashion, and give a clear message of earth or ground fault locally and to BAS if programmed. Bypass systems not incorporating earth or ground fault protection in bypass mode are not acceptable.
17. The bypass control shall include a programmable time delay bypass start with keypad indication of time delay. A Form C relay output commands the VAV boxes to open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 to 120 seconds.
18. Smoke Control Override Mode (Override 1): The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire/Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User's Manual documentation. In this mode, the system will ignore low priority safeties and acknowledge high priority safeties. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.

19. Fireman's Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for "Run-to-Destruction". The user may also force the unit into Override 2 via the serial communications link.

2.07 REDUNDANT VFDS

A. If redundant drives are needed instead of a Bypass, they shall meet the requirements as listed above and shall also have one main service disconnect or breaker and the entire cabinet and internal wiring also carry a UL 508 & cUL label. Enclosure types to be available in UL/ NEMA 1, 12, 3R, 3RX or 4X.

B. All programming and wiring to make the unit operate and transfer shall be done at the factory so the unit can be a 'turnkey' installation ready to install and connect to the BAS as if it was a standard unit. Unit shall include the following features:

1. Each drive to be equipped with fast acting drive fuses.
2. Operated Main Circuit Breaker or Disconnect Switch mechanically interlocked w/ enclosure door and lockable in the off-position w/ up to three (3) padlocks.
3. Electrically interlocked Drive Output Isolation Contactors.
4. Contactor outputs connected together at a single output distribution terminal block where external, customer provided MMPs are to be used.
5. Door mounted lights indicate individual MMPs are closed (ON), Drive Run and Fault lights for each drive, External Fault Light.
6. Voltage and power range- 3-phase, 208 to 240 V, -10/+15%, 5 to 75 HP, 3-phase, 480 V, -10/+15%, 10 to 200 HP.
7. Two analog inputs (single speed reference signal to both drives).
8. Voltage signal 0 (2) to 10 V.
9. Current signal 0 (4) to 20 mA.
10. Potentiometer reference value 10 V, 10 mA, 1 to 10 kΩ.
11. Two analog outputs 0 (4) to 20 mA, load < 500 Ω.
12. Analog signal converter to provide a single speed reference signal to both drives.
13. Auxiliary voltage 24 V DC, max. 250 mA (short circuit protected).
14. Six digital inputs 12 to 24 V DC with internal or external supply, PNP and NPN.
15. Three relay outputs (Form C).
16. Maximum switching voltage 250 V AC/30 V DC.
17. Maximum switching current 8 A at 24 V DC or 250 V AC, or 0.4 at 120 V DC.
18. Customer Terminal Block -Two User Safety/Interlock Contact Terminals with Jumper (includes one for customer door limit switch), Motor Run / External Start Signal, Speed Reference Signal.
19. Embedded Building Automation Protocols to include: BACnet (MS/TP), Johnson Controls N2, Modbus RTU and optional modules as base VFD.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Verify that mounting surface is ready to receive work. Mount the VFD(s) on the wall or at supports in locations identified on the drawings. Provide a layout drawing of VFD locations to electrical installer.

B. If the disconnect for the equipment powered by the VFD is in a location where it is probable that it will be placed in an off position prior to shutting down the VFD, the contractor is to provide electrical protection for the VFD. This may be in the form of a conduit and wire interlock between disconnect and drive or internal protection integral to the VFD.

C. Coordinate wiring and control with Control Contractor. Control installers shall install all wiring associated with control signals into the VFD and for interlock control wiring between disconnects and VFDs.

D. Electrical installer shall install all line voltage power wiring and conduit from electrical switchgear and from the VFD to the disconnect at the controlled motor. The only exception to this is when the motor and drive are factory installed on a packaged piece of equipment. In that case the wiring from drive to motor is to be installed in the factory to meet the requirements herein. Coordinate with Division 26 work.

E. Line length between VFD and driven motor shall be as short as possible. Line length shall not exceed twenty (20) feet without prior approval from Engineer.

F. Input and output power wiring shall be installed in separate grounded conduit. In addition, control wiring shall be installed in its own separate grounded conduit.

G. Use symmetric motor cable between the VFD and motor, with low inductance shield or conduit, and with all joints joined with bonding straps. MC metal clad 3 phase type cable per NEC 334-1, UL approved, 3 phase conductors and 3 ground conductors. Sheath to be continuous corrugated aluminum. Manufacturer and type to be BICC 2 kV rated Drives Cable, Anixter series 7V, or approved equal.

H. Use cable connectors with 360-degree connections to the armor conduit at both ends of motor cable. Verify electrical path from inverter cabinet entry plate to armor / conduit to motor terminal box.

I. Install an auxiliary high frequency bonding connection for potential equalization between VFD frame and building steel.

J. Unless absolutely necessary do not install disconnect between VFD and connected motor. VFD is to be furnished with a lockable disconnect.

K. Installation in Air Handlers multiple fan arrays: When a single VFD supplies multiple fans, assemble and prewire units at the factory, installing conduit and conductors between the fan motor, VFD, and terminal strips. Wiring from the VFD output terminals to the fan motor shall be Belden VFD Cable installed in conduit (295XX Series).

3.02 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify control wiring, verify power wiring, start-up the drive, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the jobsite.

B. Carrier frequency setup:

1. Set initial carrier frequency at 2 kHz.
2. Manually raise VFD speed output from 10 Hz to 60 Hz by 10 Hz increments, allowing at least 15 seconds between each adjustment. If excessive motor noise is heard at any speed, raise carrier frequency by 2 kHz increments until motor noise is no longer excessive. Do not set carrier frequency higher than 10 kHz.
3. If excessive motor noise continues to be heard at or below 10 kHz, inform owner. If the motor is provided by the VFD manufacturer, either repair, replace, or provide 5 year extended warranty on the effected motor.

C. Lockout of resonant frequencies:

1. With carrier frequency set per the above specification, manually and slowly raise VFD speed output from 10 Hz to 60 Hz by 1 Hz increments. If excessive motor, frame, or driven load noise is heard at any speed, lock out that frequency.
2. Each frequency skip shall be programmed with as narrow a bandwidth as possible, while still avoiding the most objectionable range of resonant frequencies. Each frequency skip bandwidth shall not exceed 5 Hz without approval by Engineer.

D. Training:

1. Provide one (1) hour training session to the Owner’s Representative.
2. Training to include:
   a. Demonstration of operation of bypass switch and door-mounted disconnect switches. Explain emergency operation.
   b. Demonstrate operation of operator keypads for viewing data and setting parameters.
   c. Demonstrate operation in manual mode, including setting of specific speeds.
   d. Explain the drive parameters that might require operator adjustment.
   e. Describe troubleshooting techniques and warranty procedure.

END OF SECTION 230902

SECTION 232300 - REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. Includes, but not limited to:

1. Furnish and install piping and piping specialties for refrigeration systems serving air handers with remote condensing units.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230719: HVAC Piping Insulation.

C. Section 237312 Custom Factory Air Handling Units

D. Division 26: Electrical.

1.04 QUALITY ASSURANCE

A. Codes and Standards: Comply with the requirements of the latest addition of the following:

1. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications" latest edition.
2. ASHRAE 15: Safety Code for Refrigeration Systems.
3. ASME B31.5: Refrigeration Piping and Heat Transfer Components.
4. ASTM B 280: Specification for Seamless Copper Tube for Air Conditioning & Refrigeration Field Service.

B. Contractor Qualifications: A refrigeration contractor licensed by the State shall install refrigerant piping.

C. Manufacturer Qualifications:

1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.
3. Manufacturer shall have a minimum of five years of manufacturing products related to refrigerant piping and/or fittings.

4. Products shall have an installation history of no less than five years of field operation with reliable maintenance track record.
5. Alternate system and material must be submitted with historical supporting documentation and reliability report before approval is allowed.

D. Codes and Standards:

1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.
2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes for work required, but not specifically shown in Drawings.
3. Perform all tests required by governing authorities and as required under all Division 23 Sections. Provide written reports on all tests.
4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.

E. Product Control

1. Protection: Use all means necessary to protect materials before, during, and after installation and to protect the installed work and materials of all other trades.
2. The general arrangement and locations of piping are shown on the Drawings. Changes may be necessary to accommodate work. Should it be necessary to deviate from arrangement or location indicated in order to meet existing conditions or due to interference with work of other trades, such deviations as offsets, pipe sizes, fittings sizes, rises and drops in piping that may be necessary, whether shown or not, shall be made without extra expense. Accuracy of data given herein and on the Drawings is not guaranteed. The Drawings and Specifications are for assistance and guidance, and exact locations, distances, and elevations will be governed by actual site conditions.
3. All work shall be in accordance with the applicable codes listed in Division 01. No extra charge will be paid for furnishing items required by the regulations but not specified herein or shown on the Drawings. Should there be any direct conflict between the Drawings and/or Specifications and the above rules and regulations, the rules and regulations shall take precedence.
4. All work shall be completely coordinated, and all lines, grades, slopes and vertical and horizontal locations of pipes shall be exactly determined in the field and cleared with the Owner's Representative before the installation of these items is begun. No extra compensation shall be made for failure to observe this clause.
5. The Drawings and Specifications do not undertake to list every item that will be installed. When an item is necessary for the satisfactory operation of the system, it shall be furnished without extra cost. Work called for in the Specifications, but not on the Drawings, or vice versa, shall be done as though required by both. Lack of specific mention of any work necessary for proper completion of the work in the Specifications and/or Drawings, shall not lessen the Contractor's responsibility.
6. Obtain Owner's Representative's approval prior to rerouting of existing services. Refer to Division 01 sections for alterations, shutdown and temporary construction for existing services.
7. Pipe spaces provided in the design shall be utilized and the work shall be kept within the spaces established on the Drawings.
8. Manufacturers' directions shall be followed in all cases where manufacturers of articles used in this Contract furnish directions covering points not shown on the Drawings or specified herein. Manufacturers' directions do not take precedence over the Drawings and Specifications. Where manufacturers' directions are in conflict with the Drawings and Specifications, submit these conflicts to the Owner’s Representative and receive clarification before installing the work.

9. Do not permit or cause any work to be covered or enclosed until it has been inspected, tested, and approved. Should any of the work be enclosed or covered before inspection and test, Contractor shall, at his/her own expense, uncover the work; and, after it has been inspected, tested and approved, make all repairs with such materials as may be required. Restore all work to its original and proper condition.
10. Be responsible for damage to any of this work before acceptance. Securely cover all openings, both before and after setting into place, to prevent obstructions in the pipes and breakage.
11. Repair all damage to the premises occasioned by the work. All damage to any part of the premises caused by leaks or breaks in the pipe installed under this Section of the work for a period of one (1) year after date of final acceptance of the work, shall be repaired.

F. All materials (such as insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for all refrigerant piping, valves and specialties indicating dimensions, flow capacity, pressure setting, tolerances etc.

B. Shop Drawings:

1. Submit shop drawings including plans, schematics, and riser diagrams of refrigerant piping, including dimensions of all piping.
2. Reference to associated insulation systems submitted in compliance with Section 230719 HVAC Piping Insulation.
3. Provide all details of suspension and support for ceiling hung equipment.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, valve replacement, and spare parts lists. Include this data, product data, and shop drawings in operating and maintenance manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.07 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Provide the following additional extended warranty requirements that apply to piping with mechanical type joints and fittings, such as grooved or pressed/compression type fittings.

1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
2. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
3. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

B. Do not use pre-charged refrigerant lines more than 50 feet in length.

2.02 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B88, Type K or L; or ASTM B280, Type ACR.

B. Wrought-Copper Fittings and Unions: ASME B16.22.

C. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

D. Flux: Stay-Silv white brazing flux by J.W. Harris Co or silver solder flux by Handy & Harmon.

E. Brazing Filler Metals: AWS A5.8.

1. Copper to Copper Connections:
   a. AWS Classification BCuP-4 Copper Phosphorus (6% silver).
   b. AWS Classification BCuP-5 Copper Phosphorus (15% silver).

2. Copper to Brass or Copper to Steel Connections
   a. AWS Classification BAg-5 Silver (45% silver)

3. Do not use rods containing Cadmium.

F. Manufacturers: Mueller Streamline, Nibco, Grinnell, Elkhart, or equal.

2.03 FLEXIBLE CONNECTORS

A. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.

B. End Connections: Socket ends.

C. Offset Performance: Capable of minimum 3/4 inch (20 mm) misalignment in minimum 7 inch (180 mm) long assembly.

D. Working Pressure Rating: Factory test at minimum 450 psig (3100 kPa).

E. Maximum Operating Temperature: 250°F (121°C).

F. Manufacturers: Metraflex #RAF or equal.

2.04 COPPER PRESS-CONNECT TYPE FITTINGS AND JOINTS – IN JURISDICTIONS WHERE 2018 MECHANICAL CODE IS ADOPTED

A. Flame free press fittings are allowed as a contractor option, however confirm compliance with allowable refrigerant usage, and local building codes authority having jurisdiction.

B. Product Characteristics (minimum):

1. Continuous Operating Temperature: 250°F (121°C).
2. O-Ring Temperature Rating: -40 to 300°F (-40 to 149°C).
3. Maximum Rated Pressure: 700 psi (49 bar).
4. Minimum Burst Pressure: 2,100 psi (145 bar).
5. Vacuum Pressure Capability: 20 micron.
6. Maximum Leak Rate: 0.1 oz Helium per year.
7. Vibration Resistance: Conforms to UL 109.

C. Klauke 15 kN Compatible Jaws: Hard Drawn Copper: 1/4" to 7/8" Type ACR, M, L, Type K up to 7/8". Soft (Annealed) Copper: 1/4" to 1-1/8" Type ACR, L, Type K up to 7/8".

D. Klauke 19 kN Jaws and RIDGID Compatible Jaws: Hard Drawn Copper: 1/4" to 1-3/8" Type ACR, M, L, K. Soft (Annealed) Copper: 1/4" to 1-3/8" Type ACR, L, K.

E. Tubing: The installer shall confirm the copper tubing conforms to ASTM B280, ASTM B88, or EN 12735-1.

F. Fitting Body: Conform to ASTM-B75 or ASTM-B743.

G. Fitting Sealing O-Rings: HNBR. These shall be factory installed only.

H. Compatible ODM Fittings: Material conform to C12200 copper per ASTM B280 or Cu-DHP CW024A per BS EN 12735-1.

I. Threaded Schraeder Valve Access Fittings: Schraeder style valve material and threads conform to SAE J513.

J. Threaded Fittings: Flare nuts conform to SAE J513 & SAE J533.

K. Manufacturers: Parker Sporlan #Zoomlock or approved equal.

2.05 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

B. Wrought-Steel Fittings: ASTM A234, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

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

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1" to NPS 1-1/2" (DN 25 to DN 40) and ductile iron for NPS 2" to NPS 3" (DN 50 to DN 80). Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch (180-mm) long assembly.
6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
7. Maximum Operating Temperature: 330°F (165 C).

F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
2. End Connections:
   a. NPS 2" (DN 50) and Smaller: With threaded-end connections.
   b. NPS 2-1/2" (DN 65) and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch (180-mm) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250°F (121°C).

G. Manufacturers:

1. Anaconda "Vibration Eliminators" by Anamet.
2. Vibration Absorber Model VAF by Packless Industries.
3. Vibration Absorbers by Superior Valve Co.
4. Style "BF" Spring-flex refrigerant connectors by Vibration Mountings.

5. Or equal.

2.06 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 (3450 kPa).
7. Maximum Operating Temperature: 275 F (135 C).

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 (3450 kPa).
8. Maximum Operating Temperature: 275 F (135 C).

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 (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 F (135 C).

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 (3450 kPa).
6. Manufacturers: Apollo Valves (Conbraco), Henry, Mueller, Superior, Virginia, or equal.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (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 (16-GRC) conduit adapter, and 24/115/208-volt ac coil as required.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 F (116 C).

F. Safety Relief Valves: Comply with 2010 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: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 F (116 C).

G. Thermostatic Expansion Valves: Comply with AHRI 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. Reverse-flow option (for heat-pump applications).
6. End Connections: Socket, flare, or threaded union.
7. Manufacturers: Alco, Henry, Mueller, Parker, Singer, Sporlan, or equal.

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. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter and 24/115/208-volt AC coil as required.
7. End Connections: Socket.
8. Throttling Range: Maximum 5 psig (34 kPa).
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 F (116 C).

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 (3450 kPa).
5. Maximum Operating Temperature: 275 F (135 C).

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 (3450 kPa).
6. Maximum Operating Temperature: 275 F (135 C).

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 parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 F (116 C).

L. Replaceable-Core Filter Dryers: Comply with AHRI 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. End Connections: Socket.
5. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement for suction-line filter dryers.
6. Maximum Pressure Loss: **2 psig (14 kPa)**.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 240 F (116 C).

M. Permanent Filter Dryers: Comply with AHRI 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. End Connections: Socket.
5. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: **2 psig (14 kPa)**.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 240 F (116 C).
9. Manufacturers: Alco, Mueller, Parker, Sporlan, Virginia, or equal.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 F (135 C).

O. Receivers: Comply with AHRI 495.

1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL for receivers larger than 6 inches (150 mm).

2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 F (135 C).

P. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 F (135 C).

Q. Sight Glass

1. Combination moisture and liquid indicator with protection cap.
2. Sight glass shall be full line size.
3. Sight glass connections shall be solid copper or brass, no copper-coated steel sight glasses allowed.
4. Manufacturers: Alco, Asco, Mueller, Parker, Sporlan, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide and install refrigerant piping, fittings, valves and devices as required by equipment manufacturer and as shown on the Drawings.

B. Refrigeration system connections shall be copper-to-copper, copper-to-brass, or copper-to-steel type properly cleaned and brazed with specified rods. Use flux only where necessary.

1. No soft solder (tin, lead, antimony) connections will be allowed in system.
2. Braze valve, sight glass, and flexible connections.
3. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

C. Insulate all suction and hot gas lines. Insulate liquid lines where pipe may be in close contact to humans.

3.02 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. 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.

H. 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.

I. 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.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at refrigerant piping connection to all equipment (coils, condensers, and/or compressors) as required by the manufacturer and where necessary to prevent vibration from transferring into the building structure and to minimize vibration and audible noise in occupied spaces.

3.03 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. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. 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 if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective chaseway where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. 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.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. 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.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

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

3.04 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. Steel pipe: Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."

E. 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.

F. 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 to 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

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

3.05 PRESS-FIT PIPING INSTALLATION-ZOOMLOCK (CONTRACTOR OPTION)

A. Installers shall follow all installation steps per the Sporlan #Zoomlock installation instructions. This covers examination, preparation and installation.

B. Upon delivery to the jobsite, the installing contractor shall examine the copper tubing and fittings for debris, defects, incise marks (manufacturer's engraving on tube), holes or cracks.

C. If any brazing is required, the installer shall follow the manufacturer guidelines.

D. Wrapping electrical tape over the end of a flare fitting can be used when placing foam insulation of a pipe to prevent tearing.

E. The installer shall not crimp Sporlan #Zoomlock fittings over flared style tubing (ODF). The installer can cut off the flare and crimp the Sporlan #Zoomlock fitting to the tube as long as there is a minimum of two inches of tube remaining.

F. Installer shall ensure piping is spaced such that the crimp gauge can be fit around the pipes to check for proper crimp.

G. The installer shall place Sporlan #Zoomlock fittings no closer than 1" apart.

H. The installer shall locate the copper tubing such that the crimp tool and jaws can fit around the fittings.

3.06 HANGERS AND SUPPORTS

A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Spring hangers to support vertical runs.
3. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

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

1. Up to NPS 5/8”(DN 18): Maximum span, 60” (1500 mm); minimum rod, 3/8” (9.5 mm).
2. Greater than 5/8” up to NPS 1-1/8” (DN 25): Maximum span, 72” (1800 mm); minimum rod, 3/8” (9.5 mm).
3. Greater than 1-1/8” up to NPS 2” (DN50): Maximum span, 96” (2400 mm); minimum rod, 3/8” (9.5 mm).
4. NPS 2-1/2” (DN 65): Maximum span, 108” (2700 mm); minimum rod, 3/8” (9.5 mm).
5. NPS 3” (DN 80): Maximum span, 10 feet (3 m); minimum rod, 3/8” (9.5 mm).
6. NPS 4” (DN 100): Maximum span, 12 feet (3.7 m); minimum rod, 1/2” (13 mm).

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

1. NPS 2” (DN 50): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
2. NPS 2-1/2” (DN 65): Maximum span, 11 feet (3.4 m); minimum rod, 3/8 inch (9.5 mm).
3. NPS 3” (DN 80): Maximum span, 12 feet (3.7 m); minimum rod, 3/8 inch (9.5 mm).
4. NPS 4” (DN 100): Maximum span, 14 feet (4.3 m); minimum rod, 1/2 inch (13 mm).

D. Support multifloor vertical runs at each floor.

3.07 FIELD QUALITY CONTROL

A. Perform the following 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 "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.

4. Prepare test and inspection reports.

3.08 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 (67 Pa). 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 (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.09 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - AIR DISTRIBUTION

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this Section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Ductwork - Rigid, Flexible and Fabric.
2. Diffusers, Grilles, and Registers.
3. Ductwork Specialties.
4. Flexible Connections.
5. Sealants, Adhesives and Tapes.
6. Duct Access Panels and Doors.
7. Backdraft and Relief Dampers.
8. Variable Air Volume (VAV) Terminal Units.
9. Combination Fire and Smoke Dampers.
10. Fire Dampers.
11. Smoke Dampers.
12. Control Dampers.
13. Louvers.
14. Flashings.
15. Bird/Insect Screens.
16. Sound Traps.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic Materials and Methods.

B. Section 230593: Testing, Adjusting and Balancing.

C. Section 230713: Duct Insulation.

D. Section 230900: Building Automation System (BAS) Control.

E. Division 26: Electrical.

1.04 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. ARI 885-98: Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminal and Air Outlets.
2. AMCA-210: Laboratory Methods of Testing Fans for Rating Purposes.
3. ANSI S12.23: Designation of Sound Power Emitted by Machinery and Equipment.
4. ASC-A7001: Standard for Duct Sealants.
5. ASHRAE Standard 130: Methods of Testing Air Terminal Units.
6. AHRI Standard 885: Procedures for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.
7. NFPA 90A: Standards for the Installation of Air Conditioning and Ventilating Systems.
8. NFPA 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
9. American Society for Testing and Materials (ASTM): Manufacture and test in accordance with the ASTM Standards, including:
    a. ASTM A167: Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. Type 304 or 304 stainless steel.
    b. ASTM A525: Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) Hot-Dip Process. G60 and G90 zinc-coated.
    c. ASTM A527/A527M: Standard Specification for Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
    d. ASTM C920: Standard Specification for Elastomeric Joint Sealants.

10. Underwriters Laboratory (UL): Manufacture and test in accordance with the UL Standards, including:
    a. 181:Standard for Factory-Made Air Ducts and Air Connectors.
    b. 181A: Standard for Closure Systems for Use With Rigid Air Ducts.
    c. 181B: Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors.
    d. 268A: Standard for Smoke Detectors for Duct Application.
    e. 555: Standard for Fire Dampers.
    f. 555C: Standard for Ceiling Dampers.
    g. 555S: Standard for Smoke Dampers.
    h. 723: Standard for Test for Surface Burning Characteristics of Building Materials.
    i. 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

B. Provide and construct ductwork systems in conformance with the latest editions of the following documents:

1. SMACNA HVAC Duct Construction Standards-Metal and Flexible.
2. SMACNA HVAC Air Duct Leakage Test Manual.
3. SMACNA HVAC Phenolic Duct Construction Standards.
4. SMACNA - Accepted Industry Practice for Industrial Duct Construction" for duct pressures above +5" w.g. positive pressure or below -5" w.g. negative pressure. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the two standards.
5. ASHRAE Systems and Equipment Handbook "Duct Construction" chapter.
6. ASHRAE Fundamentals Handbook "Duct Design" chapter.

C. Alternatives: The SMACNA standards and publications referenced in this Section of the specifications establish ductwork construction requirements.

1. Alternatives to these standards and publications may be submitted. Approval will be based on demonstration that such alternatives are equivalent and satisfy the functional requirements described in the referenced standards.
2. Such demonstration shall include evidence that the alternatives proposed were tested in accordance with SMACNA procedures and with test results certified by an independent testing laboratory.

D. All ductwork and equipment shall be seismically supported and braced to meet or exceed the minimum requirements of "SMACNA Seismic Restraint Manual-Guidelines for Mechanical Systems" and local building code requirements.

E. Flame/Smoke Rating: All materials, including sealants and adhesives, exposed within plenum shall be noncombustible or have a flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. All materials installed within a plenum shall meet these requirements or have a safety data sheet available to indicate that materials are non-combustible. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

1.05 DEFINITIONS

A. Class 0: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a surface burning characteristic of zero. Typically constructed of semi-rigid corrugated aluminum. This does not include sheet metal ductwork constructed per SMACNA Standards.

B. Class 1: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a flame spread index of not over 25 and a smoke developed index of not more than 50. Typically constructed of flexible ductwork, rigid fiberglass ductwork and plastic ductwork. This does not include sheet metal ductwork constructed per SMACNA Standards.

C. Flexible Air Duct (Factory-Made): Class 0 or Class 1 air ducts tested in accordance with 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Flexible ducts shall not be installed to serve more than two stories and shall not penetrate a fire-resistance rated assembly or construction. Maximum lengths of flexible ductwork shall not exceed lengths identified in this section or as limited by the AHJ, whichever is shorter.

D. Flexible Duct Connector (Factory-Made): Class 0 or Class 1 connectors tested in accordance with 12 of 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Connectors include, but are not limited to, short flexible connections between air handlers and ductwork systems, uninsulated transition fittings, specialty shapes for diffuser connections, etc. Connectors shall not penetrate a wall, floor, or ceiling. Maximum lengths of flexible ductwork shall not exceed five foot (5') lengths or as limited by the AHJ, whichever is shorter.

1.06 SUBMITTALS

A. Prior to construction, submit for approval on all materials and equipment:

1. Ductwork - Rigid, Flexible and Fabric.
2. Ductwork Specialties.
3. Flexible Connections.
4. Sealants, Adhesives and Tapes.
5. Flashings.
6. Bird/Insect Screens.
7. Duct Access Panels and Doors.
8. Backdraft Dampers.
9. Control Dampers.
10. Diffusers, Grilles, and Registers.
11. Fire/Smoke Dampers - Schedule of selected dampers must include the location, nominal size, free area velocity, and static pressure drop at free area velocity for each damper.
12. Sound Traps.
13. VAV Boxes.
14. SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

B. Shop Drawings: Provide shop drawings of sheet metal ductwork and plenums as follows:

1. Draw to a scale not less than 1/8" to one foot, with sheet sizes equal to Contract Drawings.
2. Show duct sizes, where possible use even duct sizes.
3. Show fitting details.
4. Show coordination with lighting fixtures, fire dampers, fire/smoke dampers, piping, diffusers, grilles, registers, fans, major electrical runs, cable trays and bus ducts.

C. Shop Drawings: Provide shop drawings for field erected mechanical equipment:

1. Draw to a scale of 1/2” to one foot, with sheet sizes equal to Contract Drawings.
2. Show plan, sections, elevations and details of all joints and enclosures.
3. Detail access doors and hardware.
4. Detail coil, damper, humidifier, filter and fan installations.
5. Show access space for electrical components that are part of the equipment provided and/or installed such as power and control panels on humidifiers. This shall be coordinated with Division 26 and NEC.

D. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards, and for each sheet metal system furnished on the project include:

1. System name.
2. Duct material.
3. Duct gauge.
4. SMACNA rectangular reinforcement number.
5. SMACNA intermediate reinforcement number.
6. SMACNA transverse reinforcement number.
7. Rod diameter and type.
8. Sealant type.
9. Attachment method.
10. Duct system design pressure.

E. Construction IAQ Management Plan: Collaborate with the general contractor to submit and implement an IAQ Management Plan for the construction process meeting the requirements of the SMACNA IAQ Guidelines. This plan should address the protection of the ventilation system components during construction and cleanup of contaminated components after construction is complete. SMACNA IAQ Guideline recommends control measures in five areas. The IAQ Management Plan should address how compliance has been achieved in these required five areas as follows:

1. HVAC Protection
   a. Shutdown of return side of existing HVAC system in areas affected by heavy construction.
   b. Provision of temporary filters if existing or new systems must remain operational during construction.
   c. Close the supply, return and exhaust dampers and seal duct openings in areas subject to construction dust.

2. Source Control
   a. How will reduction of contaminants be reduced at the source?
   b. What steps will be taken to employ low emitting products and sealants.
   c. How will air handling equipment be cycled off when not needed?

3. Pathway Interruption
   a. Describe how the construction space will be ventilated as required to dilute contaminants.
   b. Describe how occupied spaces adjacent to construction areas will be kept at positive pressure relative to spaces under construction.

4. Housekeeping: Describe how the following housekeeping objectives will be implemented:
   a. Reduction of dust generated by work will be suppressed.
   b. Maintaining a frequent cleaning frequency for dust and particulates.
   c. Remove spills or excess applications of solvent-containing products as soon as possible.
   d. Remove accumulated water and keep work areas as dry as possible.
   e. Protect insulation materials from exposure to moisture.

5. Scheduling: Describe how overlap of construction activity and ongoing building occupancy activities will be minimized.

F. Field Manual: Submit one copy of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible". Maintain a second copy on the project site.

G. Any ductwork installed without prior approval by the specifier, shall be replaced at the expense of the contractor.

H. The contractor must comply with the enclosed specification in its entirety. If on inspections, the specifier finds changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor’s expense.

I. At the discretion of the specifier, sheet metal gauges and reinforcing may be checked at various times to verify all duct construction is compliant.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged components. Remove damaged products from project site.

1.08 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. Construct all ducts and plenum of gauges, and with joints, bracing, reinforcing, and other construction details in accordance with the latest construction standards previously listed. Metals shall be manufactured by United States Steel, Nucor or equal.

B. Duct dimensions indicated on drawings are net, inside, clear dimensions. For internally lined ducts, add lining thickness to determine metal duct dimensions.

C. Ducts shall be constructed of material gauges and reinforcement Class per SMACNA pressurization classifications to meet 150% of the pressure requirements for external static pressure scheduled on drawings for the fans serving each system. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the code or standard. Refer to Part III - Execution for matrix of pressure and leakage requirements.

D. Ductwork gauge shall not be thinner than 26-gauge for all work.

2.02 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 (Z180) for ductwork inside the building envelope in non-corrosive environments. G90 (Z275) for ductwork installed external to the building and may be installed inside the building as an alternate to G60.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.03 DUCTWORK FABRICATION

A. Rectangular Ducts

1. Longitudinal Seams:
   a. Grooved seam flat/pipe lock (L-3), standing seam (L-4), single corner seam (L-5) or butt/corner weld for +/- 10 in. w.g. service. Snaplock and button-lock (L-1 and L-2) type joints are only allowed when ductwork is installed inside the conditioned space and when duct static pressures are less than 2" w.c. (500 Pa) or these type of joints must be reinforced with screws, soldering or welding when located in unconditioned areas or outside the insulated envelope.

2. Lateral Joints:
   a. Slip drive joints, standard seams, flanges or welding as required by SMACNA HVAC Duct Construction Standards for system static pressure and sealed airtight. Flanged and gasketed joint fittings, such as Ductmate 25/35/45, Carlisle, MEZ Industries, or equal, are acceptable joint methods, but must be sealed as described previously. Transverse duct joints shall be constructed per Figure 1-4 for types T-8 through T-25. T-1 and T-5 slip joints are NOT allowed for transverse duct joints. T-5 slip joints may be used at connections to fire and smoke dampers as breakaway connections. Joint T-2, T-3, T-6 and T-7 reinforced slip joints are allowed below 2" static pressures.
   b. Exposed Ductwork: All sealant or gaskets applied internally within joint.
   c. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
   d. Welded where required for leakproof and airtight operation and per code.

B. Round Ducts

1. Longitudinal Seams:
   a. Spiral seam (RL-1), butt weld (RL-4), or grooved seam flat/pipe lock (RL-5) for +/- 10 in. w.g. service.

2. Lateral Joints:
   a. Exposed Ductwork: Beaded sleeve joint (RT-1), crimp joint bead (RT-5), or flange type joint. All joints secured with sheet metal screws. All sealant applied internally within joint.
   b. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
   c. Welded where required for leakproof and airtight operation.

C. Elbows

1. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces, or as shown. For rectangular ductwork provide single thickness turning vanes on all short rectangular elbows less than 25" wide or provide double thickness turning vanes for short rectangular elbows 25" wide and greater. Number of vanes per SMACNA. Elbows with square throat and radius heel are NOT allowed.

D. Transitions

1. Construct transitions to not exceed the slopes identified per SMACNA HVAC Duct Construction Standards-Metal and Flexible. Slopes shall generally be no greater than 15%, and no greater than 30% where shown on the drawings.

E. Branch Connections

1. Provide 45°entry boots or radius taps for rectangular duct take-offs. Provide conical, bellmouth or 45° lo-loss boot taps for round duct take-offs. Straight 90° taps and spin-in taps are not allowed, except where round take-off duct size equals height of branch duct size. Provide volume dampers at each duct take-off for balancing. Provide insulation guards at transitions to lined ductwork.

F. Manufactured Joints

1. 316 stainless steel adjustable clamps with gaskets for connecting welded laterals, branches, and Y fittings. Manufacturer: CECO Environmental #KB Duct or equal.

2.04 RECTANGULAR DUCTWORK

A. Construct rectangular ductwork to meet all functional criteria defined in of the SMACNA HVAC Duct Construction Standards-Metal and Flexible. All ductwork must comply with all local, code requirements. Ductwork shall be constructed of galvanized steel. Diagonally cross break all panels on ducts 30 inches wide and larger, or bead using automatic bead machine with beads at 12 inches on center or less. All connections shall utilize 45° boot take-offs. Bullhead tees and straight taps are not permitted.

1. Listed manufactured ductwork system are allowed where they are installed per the manufacturer’s installation instructions and meet or exceed the requirements of the design requirements.

2.05 ROUND AND OVAL DUCTWORK

A. Round and oval ductwork shall be constructed to SMACNA round ductwork requirements of galvanized sheet steel. Comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible, based on indicated static-pressure class unless otherwise indicated. Longitudinal seams shall be spiral lock seams or continuous welded. Flat oval may be utilized in space-restricted areas. All elbows shall be long radius type with centerline radius to duct diameter of 1.5, exceptions will only be allowed at restricted space locations.

B. Round or oval duct and fitting manufacturers:

1. McGill Airflow Corporation.
2. Lindab.
3. Semco.
4. Sheet Metal Connectors.
5. Spiral Manufacturing.
6. Nordfab.
7. Spiral Fittings.
8. Or equal.

C. Flat-Oval Ducts:

1. Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

D. Transverse Joints:

1. Fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible, for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions. All transverse joints, including mechanical flange type fittings, to be externally sealed at all joints.
2. Exception: internal manufactured single or dual EPDM rubber gasket fittings do not require external sealant.
3. Transverse joints in ducts larger than 50” diameter require flanged joints.
4. Lap or snap lock seams are not permitted for round ductwork of any size.

E. Longitudinal Seams:

1. Select seam types and fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA HVAC Duct Construction Standards-Metal and Flexible. All longitudinal joints shall be sealed airtight with sealant or continuous welding.
2. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
3. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals:

1. Select types and fabricate compliant with SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-5, "45 Degree Tees and Laterals", and Figure 3-6, "Conical Tees" and "45 Degree Boot Tees" for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
2. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted.

G. Elbows:

1. Any deviation from a straight run shall be made using a gored or welded elbows or stamped elbows. Normal 90-degree elbows may include 5-gore fittings and the radius of the elbow is 1.5 times the diameter of the fabric duct. All gores shall be continuous metal or use fully welded joints/seams. Die stamped sheet metal elbows shall be fully welded on the heel and throat by an automated welder. Flexible duct elbows or adjustable gore type elbows are not allowed.
2. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces with prior approval or where shown on the drawings.

2.06 DIFFUSERS, GRILLES AND REGISTERS

A. All diffusers, grilles, and registers shall be selected to provide proper air distribution for the intended occupant application. All supply air devices shall be selected to provide a maximum air velocity of 50 fpm at three feet above the floor, unless otherwise noted. Manufacturer's representative shall carefully review Architectural and Mechanical drawings and ensure diffuser/grille/register selections will provide proper air distribution at NC 25 or less. Manufacturer at no additional expense to the Owner shall replace diffusers, grilles, and registers not providing proper distribution or excessive noise at scheduled airflow.

B. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper where individual duct mounted balancing dampers are not provided.

C. Refer to schedule on drawings for sizes, capacities and patterns.

D. Manufacturers: Titus, Krueger, Price, Metal Aire, Nailor, Anemostat, Carnes, Tuttle&Bailey, or equal.

2.07 FLEXIBLE DUCTWORK

A. Pre-insulated flexible round ductwork, minimum one-inch thick, Class 0 or Class 1, may be utilized for final connections to each air outlet and inlet, unless shown otherwise on the plans. Uninsulated flexible ductwork, flexible PVC or flexible aluminum duct products are not allowed. Duct shall have a minimum R-4.2 (one-inch thick) for ductwork enclosed in conditioned spaces and R-8.0 (two-inch thick) for ductwork installed in unconditioned spaces. Maximum length of flexible ductwork in each low-pressure branch shall not exceed five feet (5') and maximum flexible connector lengths shall not exceed five feet (5').

B. All connections shall utilize welded conical tees, aluminum conical fitting, or manufacturer high efficiency branch take-offs. Spin-in type or other types of butt tees, bullhead tees or straight taps ARE NOT permitted. Manufacturers: Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO, or equal.

C. Dampers regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

D. Flexible ductwork for low pressure systems with positive static pressure up to 2" w.g. positive pressure and negative pressured up to 1/2" w.g. suitable for both terminal unit connection and diffuser/grilles. Flexible ductwork fittings may be used at seismic expansion joints and to accommodate vertical drift between building levels. Fabrication shall include a multiple laminate of aluminized polyester/mylar, fiberglass insulation, and polyester, mechanically locked to galvanized steel helix without adhesives, exterior fiberglass insulation and fire-retardant polyester/mylar outer jacket. Manufacturers: Casco #L-181M, Flexmaster #Type 5B, Thermaflex #M-KC or EverClean, or equal.

E. Flexible Duct Clamps/Draw Bands: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes up to 18 inches to match duct size. Use permanent screwed attachment systems for ducts sizes larger than 18".

2.08 DUCTWORK SPECIALTIES

A. General: Where specifically called for, materials for use in fabricating ductwork specialties shall be identical to that used to fabricate ductwork. See drawings and Part 3, Execution for schedule.

B. Flexible Connections (Indoor Applications):

1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame. Hypalon, teflon or silicone coated fabrics may be acceptable.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
7. Neoprene-only connectors are not allowed due to non-compliant surface-burning characteristics.
8. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal up to maximum dimensions of 4" metal, 6" fabric, 4" metal as required by application.
9. Manufacturers: Ventfabrics #Ventglas, Duro Dyne, Q Industries, Kinetics, Ductmate Proflex or Elgen.

C. Flexible Connections (Outdoor Applications):

1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Hypalon (chlorosulfurated polyethylene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant. Resistant to sunlight, ozone and weather.
4. Minimum density of 26 oz. per sq. yard.
5. Temperature range: -50°F to 275°F

7. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal up to maximum dimensions of 4" metal, 6" fabric, 4" metal as required by application.
8. Provide flexible cloth insulating blanket to encase flexible connections to maintain ductwork insulation integrity as follows:
   a. Jacket shall be UV and ozone resistant with Velcro attachment.
   b. Service Operating Temperature: 0-350°F.
   c. Jacket and Liner: silicon or teflon impregnated fiberglass or mineral wool cloth.
   d. Insulation: Aerogel, 2" thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
   e. Fastening: 2" Nomex Velcro or 1" straps and stainless steel D-rings.
   f. Thread: Kevlar/stainless steel thread.
   g. Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, or equal.
9. Manufacturers: Ventfabrics #Ventlon, Duro Dyne, Kinetics, Ductmate Proflex or Elgen.

D. Volume and Splitter Dampers: Galvanized sheet metal blade and frame with Ventfabrics Inc., Ventlok operating hardware. For accessible dampers, provide #641 self -locking dial regulators and #644 self-locking dial regulators for insulated ductwork, #637 square end bearing, and #635 spring end bearing, as applicable. For inaccessible dampers, provide #666 or #677 concealed locking damper regulator with bearings as above. For static pressures above 3"wg, provide #640 HiVel dial regulator and #609 HiVel end bearing for accessible dampers. Regulators shall extend to and through ceiling with neatly installed hardware at the finished ceiling. For inaccessible dampers requiring adjustment through diffusers use Young Regulator, Bowden cable control system.

E. Multi-louver Volume Dampers: 16-gauge galvanized steel frame. Opposed, 6" wide, 16-gauge galvanized steel blades. Concealed linkage in frame. Ruskin #CD35/OBD or equal.

F. Ducts Through Roof: Unsupported duct penetration through a roof, without roof curbs, shall be 16-gauge (minimum), flashed and counterflashed, and provided with storm collars to secure a watertight construction.

G. Bird/Insect Screens: 19-gauge (0.91 mm) galvanized after weld wire mesh (minimum gauge), 1/2" x 1/2" openings (maximum) set in a galvanized steel frame. Or, 23-gauge (0.57 mm) galvanized after weld wire mesh (maximum gauge), 3/8" x 3/8" openings (minimum) set in a galvanized steel frame. Verify minimum requirements per local code for outdoor air intake and exhaust outlets.

H. Seismic Duct Connector (Indoors): Provide flexible connector at penetrations between two structural elements where the structural design has designated allowable seismic or settlement movement. Flexible EPDM elastomeric fabric bonded to a 1/4" steel perimeter flange on each end. EPDM shall be rated for maximum temperature of 250°F and 3 psi maximum. Connector shall be rated to meet or exceed structural design requirements with a minimum of 3" for axial compression, 3" axial extension, and 3" lateral deflection. Manufacturers: Mercer Rubber Co #ME-3/MI-9-3, Mason Industries #MD-4/MI-9, Flexicraft, Garlock, Hyspan, or equal.

I. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork not exceeding 18" (450

mm) diameter, and suspended diffusers/grilles/terminal units. Alternate to metal strap options per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

2.09 ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct." Access doors shall be insulated hollow core double construction. Access doors in exhaust ducts shall be of same, or heavier, gauge material as duct in which installed.

B. Casing Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 9-16, "Casing Access Doors." Access doors shall be insulated hollow core double construction of same, or heavier, gauge material as duct in which installed.

C. Minimum door size shall be 12" by 12" for simple manual access and up to 24" by 24" where personnel must pass through infrequently. Provide 20" x 54" (minimum) door for access to filters and more frequent maintenance.

D. Maximum door leakage shall not exceed 10 cfm/sq.ft. at maximum operating pressure. Doors larger than four sq.ft. in area shall open against pressure.

E. Doors:

1. Double wall, rectangular.
2. Galvanized sheet metal with insulation fill and gauge thickness as indicated for duct pressure class. Minimum 1” insulation thickness for doors up to 24” tall and 2” thick insulation for larger door assemblies as required per energy code. Insulation not required in exhaust duct access doors as allowed by local code.
3. Latches: Steel cam or lever type. Access doors shall openable by hand with no tools.
4. Vision panel shall be provided on doors 24” x 60” and larger.
5. Fabricate doors airtight and suitable for duct pressure and air leakage class.
6. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets for doors up to 24” tall. For larger doors provide 1-1/2" by 1/8" flat stock or 14-gauge angle frame.
7. Gaskets: Closed cell neoprene rubber, 1” x 1/4" (minimum).
8. Access Door Manufacturers (Small Dimensions, Low Pressure Rating): CESCO, Pottorff, Ruskin, Vent Products, Air Balance Inc., Ductmate Sandwich, United Enertech, or equal, as required by size and pressure application.

F. Hinges and Latches:

1. Access doors up to 14 by 14 inches (300 x 300 mm) square: Two hinges or continuous piano hinge and one sash lock. Doors shall not be removable.
2. Access doors up to 16 by 24 inches (400 by 600 mm) square: Two hinges or continuous piano hinge and two sash locks (minimum). Doors shall not be removable.
3. Access doors up to 24 by 48 inches (600 by 1200 mm): Three hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
4. Access doors larger than 24 by 48 inches (600 by 1200 mm): Four hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
5. Latch Manufacturer: Ventlok #100 Series hinges and latches on low pressure system doors up to 18 " maximum dimension, #200 Series on larger low pressure system doors, #333 Series on high pressure systems with stops, or equal.

2.10 DUCTWORK SEALANT

A. Duct tape is not allowed.

B. Solvent-based and oil-based sealants are not allowed indoors.

C. Seal outside of all transverse joints, including mechanical joint flanges and corners, similar to Ductmate, on all supply, return, exhaust, and outside air intake ducts.

D. All sealant systems for outdoor application to be suitable for use in exposure to water, sunlight, temperatures extremes associated with project location.

E. All sealant systems for indoor application to be meet VOC limits as specified in South Coast Air Quality Management District (SCAQMD) Rule #1168 limiting VOC's to 80 grams/liter for duct liner adhesives and 250 grams/liter for duct sealants.

F. Indoor Application Water-Based Sealant for Lateral Duct Joints:

1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
   a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
   b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
   c. Flexibility on 1/4" mandrel.
   d. Freeze/thaw stability - 5 cycles.
   e. Service temperature: -20°F to +200°F (-29°F to +93°C).
   f. ASTM 5590; Resistance to mold, mildew and water.
   g. Meet all SMACNA seal classes.
   h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.

2. Manufacturer: Carlisle (Hardcast) #Iron Grip 601, Design Polymerics #DP1010, Ductmate #FIBERseal or equal.

G. Indoor Application Water-Based Sealant for Longitudinal Duct Seams:

1. Spiral and oval lockseams are not longitudinal seams and do not require additional duct sealant, however, lateral joints must be sealed.
2. Joints that are not fully welded shall be sealed.

3. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
   a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
   b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
   c. Flexibility on 1/4" mandrel.
   d. Freeze/thaw stability - 5 cycles.
   e. Service temperature: -20°F to +200°F (-29°F to +93°C).
   f. ASTM 5590; Resistance to mold, mildew and water.
   g. Meet all SMACNA seal classes.
   h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.

4. Manufacturer: Carlisle (Hardcast) #Flex-Grip 550 or #Iron Grip 601 or #Spray-Seal, Ductmate #PROseal or #FIBERseal, Design Polymerics #DP1010 or #DP1020 or #DP 1010 Spray, or equal.

H. Indoor Application Water-Based Joint and Seam Sealant with Extended 10-Year Material Warranty:

1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
   a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
   b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
   c. Flexibility on 1/4" mandrel.
   d. Freeze/thaw stability - 5 cycles.
   e. Service temperature: -20°F to +200°F (-29°F to +93°C).
   f. ASTM 5590; Resistance to mold, mildew and water.
   g. Meet all SMACNA seal classes.
   h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.
   i. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal and #Aluma-Grip AFT-701 rolled sealant, or equal system.

2. And, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed by a 30-mil rolled sealant. Rolled sealant shall be comprised of a 2-mil foil faced with 28 mils of butyl adhesive/sealant conforming to the product specifications. Rolled sealant shall have the following physical properties:
   a. Peel Strength: 16 lbs. per linear inch.
   b. Tensile strength: 955 psi
   c. Elongation: 560%
   d. Bonding time: Instant with full bond in 24 hours.
   e. Resistance to mold, mildew and water.
   f. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
   g. Service temperature: -20°F to +200°F (-29°F to +93°C).
   h. Surface burning characteristics: Flame spread/smoke developed rating of 20/40, tested in accordance with UL 723.
   i. VOC: 0 g/l
   j. Meet all SMACNA seal classes.
   k. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, and 6" water gauge.
   l. Manufacturer: Carlisle (Hardcast) #Aluma-Grip AFT-701 rolled sealant, or equal.

I. Outdoor Application Two-Part Tape Sealing System:

1. Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermally with tape to form hard, durable airtight seal.
2. Manufacturer: Carlisle (Hardcast) #Two Part II, McGill Uni-Cast, or equal.

J. Outdoor Application Low VOC Solvent Based Joint and Seam Sealant:

1. Flexible, adhesive sealant, suitable for outdoor application on joints and seams.
   a. Sealant shall be solvent based synthetic elastomeric. Water and UV resistant. Crack and peel resistant.
   b. Compliant with ASMT E84 and UL 723. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0 after cured.
   c. Freeze/thaw stability - 5 cycles.
   d. Service temperature: -20°F to +190°F (-29°C to +88°C).
   e. VOC: 44 g/l.
   f. ASTM 5590 compliant for resistance to mold, mildew and water.
   g. Meet all SMACNA seal classes.
   h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.
2. Manufacturer: Design Polymerics #DP1090 or equal.

K. Rolled (Tape) Mastic Sealant for indoor and outdoor application on flat sheet metal duct joints. Aluminum substrate with modified butyl sealant. Compliant with UL 181B-FX. Rolled sealant shall have the following physical properties:

1. Peel Strength: >10 lbs. per linear inch.
2. Bonding time: Instant tack with full bond in 24 hours.
3. Resistance to mold, mildew and water.
4. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
5. Service temperature: -20°F to +180°F (-29°C to +82°C).
6. Surface burning characteristics: Flame spread/smoke developed rating of 5/25, tested in accordance with UL 723.
7. VOC: 0 g/l.
8. Meet all SMACNA seal classes.
9. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6" and 10" water gauge.
10. Roll width as required to maintain minimum 3/4" adhesion width on each side of joint.
11. City of Los Angeles RR#8069 approved.
12. Manufacturer: Carlisle (Hardcast) #Foil-Grip 1404-181BFX rolled sealant, or equal.

L. Manufacturers of duct sealant systems for various ductwork applications: Design Polymerics, Tremco, Dure Dyne, Carlisle Hardcast, Ductmate, Mon-Eco Industries, Sikaflex, and McGill AirSeal LLC.

2.11 PRE-INSULATED DUCT SYSTEM FOR OUTDOOR AND UNCONDITIONED LOCATIONS

A. General

1. Pre-manufactured exterior ductwork to be a double layered duct system using the Pal Phenolic duct panels pre-fabricated and assembled into inter-locking sections. This as an

alternate method to contractor fabricated double wall sheet metal ductwork with internal insulation.

2. All fabricated duct segments and fittings shall be designed in accordance with "SMACNA HVAC Phenolic Duct Construction Standards" latest edition.
3. Duct sizes are limited to maximum 80" x 80" operating up to 4" w.g. positive or 3" w.g. negative pressure class.

B. System

1. The panels used in the fabrication of the ductwork system shall Pal Phenolic Duct rigid phenolic insulation panels with a thermal conductivity of 0.1977 BTU-in/hr•ft^2 °F and a minimum compressive strength of 29 psi, as manufactured by Pal International.
2. Assembled panels shall be a minimum of 2" thick and minimum R-10 insulating value.
3. Pal Phenolic Duct rigid phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC–free rigid Phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides with 60-micron aluminum internal liner and a 200-micron aluminum external liner. Both liners are to be solid aluminum with no perforations.
4. All other components required for the fabrication of the system shall be from the Pal Phenolic Duct System guidelines including the sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges.
5. Exterior weatherproof cladding shall be a 5 ply, zero permeability vapor barrier, puncture resistant, tear resistant, flexible, and meet UL-1709.

C. Fire and Smoke Performance

1. The rigid phenolic insulation panels shall achieve the following fire and smoke performance requirements:
   a. ASTM E 84–low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   b. UL 723 –low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   c. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A & 90B.

D. Sealant Material

1. All internal seams must be fully sealed with an unbroken layer of Pal Phenolic sealant.
2. Each ductwork section must be duly connected with an inter-locking, double sealed jointing system. Sufficient sealant should be applied to each layer in order to seal the rigid phenolic insulation panels and ensure minimum air leakage.
3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
4. All external seams where two separate panels join must be tiger clipped, taped and jacketed in watershed fashion whenever possible to achieve a permanent bond with weather protection and a smooth appearance.

E. Manufacturers: AQC Industries #QDuct, KoolDuct or equal.

2.12 PLENUMS AND EQUIPMENT CASINGS

A. Construct casings and plenums in conformance with SMACNA. Minimum Pressure Class: Unless otherwise indicated construct plenums and casings to withstand either a negative or positive static pressure of 4" w.g.

B. Single-Wall Casings and Plenums

1. Construct in accordance with SMACNA Standards.
2. Use steel-angle-reinforced standing-seam construction.
3. Locate intermediate bracing angles bolted to the casing 24 inches on centers.
4. Construct for static pressure indicated or for the maximum fan static pressure whichever is less.
5. Bolt to 3" high concrete pads using 1-1/2" x 1-1/2" x 1/4" thick galvanized steel structural sections.

C. Double-Wall Insulated Ductwork

1. Construct in accordance with SMACNA Standards. Provide insulation thicknesses to meet or exceed the minimum required by local energy codes.
2. Provide 2" (minimum) thick prefabricated double wall insulated metal panel assemblies, with 16-gauge aluminum or 18-gauge minimum galvanized steel outer sheets.
3. Provide 22-gauge galvanized steel inner sheets to encapsulate the insulation.
4. Casings shall be fully metal enclosed, insulated with 2" thick (minimum) rigid fiberglass insulation and conforming to NFPA 90A, with maximum flame spread of 25 and maximum smoke developed of 50.
5. Field or factory fabricate to size and configuration indicated on the drawings, using field verified dimensions.
6. Provide coordinated shop drawings.
7. Reinforce spans 10' or greater with structural steel sections to yield maximum deflection 1/4" at minus 10" w.g. or plus 10" w.g. static pressure.
8. Provide openings and doors, all factory framed, and reinforced with 304 stainless steel structural sections.
9. Construct doors of same material as casings, of sizes and locations indicated on the drawings but not smaller than 18" by 54", and conforming to SMACNA.
10. Provide doors, hinges and hardware factory fabricated and mounted.
11. Door swings shall open against air pressure, with door latches operable from either side.
12. Provide door seals with neoprene gaskets, which have an airtight seal.
13. Provide each door with a 10" by 10" wire reinforced double pane window.
14. Bolt base channel to 3" high concrete pads.

2.13 CONTROL DAMPERS

A. General: Low leakage dampers shall be Class 1A with a maximum leakage rate of 3 cfm/ft^2 at 1.0 in. w.g. pressure difference when tested to AMCA Standard 500.

B. Damper Type One: Airfoil Low Leakage Dampers (Galvanized Steel or Aluminum)

1. Application: Commercial supply, return, and general exhaust air systems up to 3,000 fpm velocity. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.

2. Frames to be 5" x 1"x 16-gauge galvanized steel hat-shaped channel or 5" x 1" x 0.125 anodized extruded aluminum hat channel with corner reinforcement.
3. Blades: Airfoil shaped, single piece, 6" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
    a. Action:
        1) Parallel blade for open and closed control, and economizer dampers.
        2) Opposed blade for modulating and air flow measurement control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
7. Linkage to be concealed in frame.
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Damper position indicator switch(es) as required by control sequence.
11. Manufacturer: Ruskin #CD60 or #CD50, Swartout, NCA PBD/OPD-AF-101, American Warming, Tamco, Air Balance, Greenheck, Pottorff, Nailor or equal.

C. Damper Type Two: Airfoil Low Leakage for Coastal and High Moisture Environments (Aluminum)

1. Application: Commercial supply, return, and general exhaust air systems where damper will be exposed to damp marine air and where velocity is less than 3,000 fpm. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.
2. Frame to be 5" x 1" x 0.125 anodized extruded aluminum hat channel with silicon side seals and corner reinforcement.
3. Blades: Airfoil shaped, single piece, 6" wide (maximum), 6063-T5 anodized aluminum.
    a. Action:
        1) Parallel blade for open and closed control, and economizer dampers.
        2) Opposed blade for modulating and air flow measurement control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 1/2" diameter steel, hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel sleeve or molded synthetic sleeve.
7. Linkage to be concealed in frame.
8. Stainless steel hardware.
9. Damper position indicator switch(es) as required by control sequence.
10. Manufacturer: Tamco #SW Series, Ruskin #CD50, Swartout, NCA, Pottorff, American Warming, Air Balance, Greenheck or equal.

D. Damper Type Three: Heavy Duty Fan Discharge Control

1. Application: Velocity over 3,000 fpm as fan outlet damper.
2. Frames to be 8" x 2" x 12-gauge steel channel (minimum).
3. Blades to be 8" wide (maximum), 0.080 thick extruded aluminum airfoil design.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 3/4" diameter steel, hex-shaped, mechanically attached to blade.
6. Bearings: Stainless steel sleeve type pressed into frame.
7. Linkage to be out of airstream with 10-gauge galvanized steel clevis type arms with crank lever operator.
8. Provide with mill finish on blades and frame.
9. Maximum temperature rating to be 300°F.

10. Manufacturer: Ruskin #CD102, Nailor, Swartout, Pottorff, American Warming, Air Balance, Greenheck or equal.

E. Damper Type Four: Low Leakage Airfoil Insulated Dampers

1. Application: Air handler intake and exhaust. Damper shall be rated for -25°F to 180°F (-32°C to 83°C) minimum operating range.
2. Frames to be 5" x 1"x 16-gauge galvanized steel hat-shaped channel or 5" x 1" x 0.125 anodized extruded aluminum hat channel with corner reinforcement.
3. Blades: Insulated, single piece, 6" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum, R-3.3.
   a. Action: Parallel blade for open and closed control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
7. Linkage to be concealed in frame.
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Damper position indicator switch(es) as required by control sequence.
11. Manufacturer: Ruskin #IL35, Greenheck, Pottorff, Tamco, or equal.

F. Damper Type Five: Ultra Low Leakage Airfoil, Double Row Dampers

1. Application: Natural ventilation wall inlets and outlets with parallel (double row) damper blades. Damper shall be rated for -72°F to 275°F (-58°C to 135°C) minimum operating range.
2. Frames to be 8” x 1” steel or aluminum channel thermally broken with insulation within frame channels.
3. Blades: Airfoil shaped, single piece, 4" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
   a. Action: Parallel blade for open and closed control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
7. Linkage to be concealed in frame
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Damper position indicator switch(es) as required by control sequence.
11. Manufacturer: Ruskin #CD40x2, Greenheck, Pottorff, Tamco, or equal.

2.14 BACKDRAFT AND RELIEF DAMPERS

A. Light Duty Counterbalanced Backdraft Damper

1. Applications: Low pressure ductwork systems, including outside air intake and exhaust locations.
2. Frame: Extruded aluminum channel frame with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.025” (0.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.

4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 1,500 fpm (7.6 m/s).
7. Maximum back pressure of 2.0" w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.06" w.g. (15 Pa).
9. Manufacturer: Ruskin #CBD2, Greenheck #WD Series, or equal.

B. Heavy Duty Counterbalanced Backdraft Damper

1. Application: Medium pressure air ductwork and generator exhaust.
2. Frame: Galvanized steel, 16-gauge (1.5 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.05" (1.2 mm) minimum formed aluminum. Maximum 6" wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 2,500 fpm (12.7 m/s).
7. Maximum back pressure of 4.5" w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.20" w.g. (50 Pa).
9. Manufacturer: Ruskin #BD6, Greenheck #HB Series, Nailor #1380, or equal.

C. Barometric Relief Damper

1. Applications: Gravity hood exhaust, room pressurization control and stairwell pressurization relief.
2. Frame: Extruded aluminum channel frame, 0.090" (2.3 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.063" (1.6 mm) minimum formed aluminum. Maximum 6" wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable on-blade counterweights for tuning of start-to-open and full open blade operation.
5. Axle: 3/8" (9.5 mm) galvanized steel rod with roller bearings.
6. Mounting: Vertically or horizontally oriented as shown on the drawings.
7. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
8. Maximum back pressure of 2.0" w.g. (0.5 kPa).
9. Start-Open Pressure: 0.05" w.g. (12.5 Pa).
10. Manufacturer: Greenheck #BR-30 for vertical mounting, Greenheck #BD-10 for horizontal mounting, or equal.

D. Round Counterbalanced Backdraft Damper

1. Dampers shall be of the two-blade design with separate axles. Blades shall be retained in closed position with tensioned spring and field adjustable for required opening pressure. Not allowed for installation in dryer exhaust, kitchen exhaust or bypass air applications.
2. Frame: 20-gauge (1.0 mm) minimum galvanized steel.
3. Blade: 0.016" thick (0.40 mm) minimum aluminum.
4. Blade Seals: Vinyl foam.
5. Axle: 3/16" (4.8 mm) minimum steel.
6. Maximum Velocity: 1,000 fpm (7.6 m/s).
7. Maximum Pressure Drop Fully Open: 0.06" w.g. (125 kPA).

8. Manufacturer: Ruskin #BDR2, Greenheck #WDR-53 or equal.

E. Light Duty Non-Counterbalanced Neoprene Backdraft Damper

1. Applications: Low pressure exhaust from small mechanical equipment less than 2,500 cfm.
2. Frame: 16-gauge galvanized steel with flanges to match ductwork requirements.
3. Blades: Neoprene coated fiberglass. Maximum 6” wide blades.
4. Mounting: Vertically or horizontally oriented as shown on the drawings.
5. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
6. Manufacturer: Ruskin #NMW2 or equal.

2.15 LOUVERS

A. Louvers are generally to be provided under Division 8 or as specified in the equipment schedules on the drawings. Where louvers are not covered on architectural plans and specifications, contractor is to provide louvers with the following minimum specifications:

1. Louvers to be 6" deep, 35° drainable fixed blade design, constructed of galvanized steel or extruded aluminum, or as specified on the plans.
2. Frames to be constructed of 6" deep channel, aluminum or galvanized steel.
3. Provide with 1/2" x 1/2" aluminum mesh bird screen mounted on backside of louver.
4. Finish/color per architect/engineer's review of manufacturers color chart or custom color matching if required.
5. Manufacturer: Ruskin #ELF6375DX or equal.

2.16 DUCT SMOKE DETECTORS (DSD)

A. Duct mounted photoelectric smoke detector. One required for each heating or cooling system supplying air in excess of 2,000 cfm, for systems serving more than one occupancy type, and for control of each combination fire/smoke damper when not controlled by Division 26 area wide detection system.

B. Coordinate with Division 26 work and electrical installer for power to smoke detector. Detector shall be installed in the system in compliance with Chapter 6 of the Mechanical Code and NFPA-72. Provide 24-volt power supply option and/or 24-volt transformer as required to coordinate with Division 26.

C. Coordinate with control installer to assure that detector shall shut down the air-moving equipment when smoke is detected and close associated damper actuator(s). Sensor shall be selected to operate with air velocity rating from 100 to 4000 fpm. Provide with metal sampling tube. Provide remote test and reset station at ceiling or as otherwise indicated. Duct smoke detector shall be installed in the supply or return in compliance with the applicable mechanical or building code. Coordinate with Section 230900 and 230593 work.

D. Where return air risers serve two or more stories and serve any portion of a return air system having a design capacity greater than 15,000 cfm, smoke detectors shall be installed at each story. Duct smoke detectors shall be located upstream of the connection between the return air riser and any air ducts or plenum. Provide additional duct smoke detectors where required by NFPA-90A.

E. Manufacturer: To be compliant with SIMPLEX, per OSU Standards.

2.17 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

A. General:

1. Provide UL labeled 3 hour rated fire dampers at 3-hour and greater penetrations.
2. Provide UL labeled 1-1/2 hour rated fire dampers at less than 3-hour penetrations.
3. All dampers to be certified under the latest UL Standard. Certification based on former non-current standards is unacceptable.
4. All damper installations to conform with NFPA 90A and manufacturer's installation instructions. Details on drawings are shown for reference only.
5. Install in ducts passing through walls, floors, and ceilings as required by code. Refer to Architectural and Mechanical plans for damper locations.
6. Provide fire, smoke and fire/smoke dampers in locations as required by local code and NFPA-90A and 92A.
7. Provide sleeves, slip joints, retaining angles, duct access doors, ceiling access panels, etc., as required to check and service the fire dampers. Slip or break away joints are not allowed to be taped or sealed.
8. Access doors shall be tight fitting hinged with hand operable cam or lever type latches. Access shall not require the use of keys, tools or special knowledge. Removable doors are not allowed. The access point shall permanently labeled with 1" (25 mm) high letters: "FIRE DAMPER", "SMOKE DAMPER", or "FIRE/SMOKE DAMPER".
9. All dampers to be designed for use in dynamic systems.
10. Dampers shall be rated for Leakage Class I. Leakage Class II may be used if damper size is smaller than available Leakage Class I dampers.
11. Dampers shall be certified for use by State and local authorities.
12. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress doe to twisting, racking, bowing, or other installation error. Do not install actuators in area where moisture can penetrate actuator or where temperature exceeds 120°F.
13. All fire dampers shall be sized to provide equivalent free area through the damper equal to, or greater than, the free area of the connecting ductwork. Upsize fire dampers as required to minimize pressure drops. In no case is the damper pressure drop to exceed 0.20" w.g., but ideally less than 0.10" w.g .for low velocity dampers, as designed for total system static pressure allowance. Refer to submittal requirements in Part One of this section and requirements on the drawings.

B. Radiation Ceiling Fire Dampers:

1. Bladed ceiling fire damper constructed and tested in conformance with UL-555C (dynamic rating).
2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Installation shall be in accordance with damper manufacturer's instructions.
3. Provide fire blanket where required to obtain listed fire rating.
4. Manufacturers: Ruskin #CFD Series, Greenheck #CRD Series, or equal by Pottorff, Cesco, Nailor, or Air Balance.

C. Dynamic Fire Dampers (FD) for use in Dynamic and Static Systems:

1. Curtain fire damper constructed and tested in conformance with UL-555C.

2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Fire damper shall be equipped for vertical penetrations with manufacturer supplied sleeve. Installation shall be in accordance with damper manufacturer's instructions.
3. Curtain damper shall not be located in air stream during system operation, Style B or C. Clear inside opening through fire damper is to match clear inside opening of duct. Fire dampers in lined ducts are to match size of sheet metal duct.
4. Dynamic Closure Rating Velocity: 2000 fpm (minimum).
5. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10" w.g. at full air flow.
6. Pressure rating: 4" w.g.
7. Manufacturers: Ruskin #DIBD Series, Greenheck #DFD Series, or equal by Pottorff, Air Balance, Nailor or CESCO.

D. Combination Fire and Smoke Dampers (FSD):

1. Required Locations:
   a. Install at ducted penetrations through rated fire barriers, fire walls, rated ceilings, rated corridor ceilings, shaft enclosures, and smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
   b. Per NFPA-90A install smoke dampers or combination fire/smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.

2. General Requirements:
   a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.
   b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
   c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.
   d. Mounting: Vertical or horizontal
   e. Frame: 5" wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
   f. Sleeve: Minimum 20-gauge thickness and minimum 16" long.
   g. Bearings: Stainless steel, permanently lubricated sleeve type.
   h. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination fire and smoke dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
   i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
   j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation

coordinate with Division 26 to align power requirements at no additional cost to Owner.

k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.
   1) Actuator shall carry a manufacturer's 5-year warranty.
   2) Damper position shall fail closed on loss of power.
   3) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
   4) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in.lbs. torque.
   5) Stall and instantaneous type actuators are not acceptable.
   6) Do not install in areas where moisture can penetrate damper or actuator, nor where actuator temperature exceeds 122°F (50°C).
   7) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:
   a. Provide open or closed indicator assembly consisting of a single pole, double throw switch used to indicate damper blade position. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch. Or, provide optional actuator end switches to indicate damper open and damper closed positions. Coordinate with fire alarm system and FireFighter's Smoke Control Panel for remote indication and damper override control.
   b. Provide a damper mounted testing module to permit test cycling of the damper actuator assembly as required for start-up testing and maintenance.
   c. Provide integral duct smoke detector and coordinate with Division 26 for area smoke detection and comply with NFPA-90A and NFPA-72. All wiring to be provided by Division 26 installers. In buildings not equipped with an approved fire alarm system the smoke detection activation shall cause a visual signal and audible signal in a normally occupied area and be identified as air duct detector trouble.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.
   e. Temperature limited override: Provide a two-temperature electronic high temperature limit. A primary sensor at 165°F (or higher temperature as dictated by AHJ or Building Code) can be bypassed by an external electrical signal allowing the damper to reopen and remain open until the temperature reaches the setting of the secondary sensor at 350°F at which point the damper is closed and remains closed. Both sensors are to be equipped with manual resets.

4. Low Velocity Applications (1500 fpm or below):
   a. Maximum Rate Velocity: 1500 fpm.
   b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10" w.g. at full air flow.
   d. Pressure rating: 4" w.g.

e. Manufacturers: Ruskin #FSD37 or #FSD60 or #FSD60-3, Ruskin #FSDR25 or #FSDR60 round style, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-311M, or equal by Pottorff, Nailor, Cesco or Air Balance.

5. High Velocity Applications (Greater than 1500 fpm):
   a. Maximum Rate Velocity: 4000 fpm.
   b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20" w.g. at full air flow.
   d. Pressure rating: 4" w.g.
   e. Manufacturers: Ruskin #FSD60 or #FSD60-3, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-331, or equal by Pottorff, Nailor, Cesco or Air Balance.

6. Low and Medium Velocity Round Applications (3000 fpm or below):
   a. Maximum Rate Velocity: 3000 fpm.
   b. Style: Two piece 14-gauge thickness galvanized steel with mechanically fastened silicone edge seals
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.15" w.g. at full air flow.
   d. Pressure rating: 4" w.g.
   e. Manufacturers: Ruskin #FSDR25 or #FSDR60, Greenheck #FSDR-511, or equal by Pottorff, Nailor, Cesco or Air Balance.

7. Corridor Ceiling Application:
   a. Maximum Rate Velocity: 1500 fpm.
   b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10" sp w.g. at full air flow.
   d. Pressure rating: 4" w.g.
   e. Manufacturers: Ruskin #FSD60-C, Greenheck #CFSD-211, or equal by Pottorff, Nailor, Cesco or Air Balance.

E. Smoke Dampers (SD):

1. Required Locations:
   a. Install at rated smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
   b. Per NFPA-90A install smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.

2. General Requirements:
   a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.
   b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
   c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.
   d. Mounting: Vertical or horizontal
   e. Frame: 5" wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
   f. Sleeve: Minimum 20-gauge thickness and minimum 12" long.

g. Bearings: Stainless steel, permanently lubricated sleeve type.
h. Smoke damper shall be equipped for vertical wall penetrations with manufacturer supplied sleeve and fail closed on loss of power. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination smoke and fire dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation coordinate with Division 26 to align power requirements at no additional cost to Owner.
k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.
    1) Actuator shall carry a manufacturer's 5-year warranty.
    2) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
    3) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in-lb torque.
    4) Stall and instantaneous type actuators are not acceptable.
    5) Do not install in areas where moisture can penetrate damper or actuator nor where actuator temperature exceeds 122· F (50°C).
    6) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:
    a. Provide open or closed indicator option assembly consisting of a single pole and a double throw switch used to indicate damper blade position. Output from switch to position indicator light (LED, provided by Division 26) is by automatic temperature control contractor. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch.
    b. Provide a test module to permit test cycling of the damper/actuator in the field
    c. Provide integral duct smoke detector or coordinate with Division 26 for area smoke detection. Division 26 to provide all wiring.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.

4. Low Velocity Applications (1500 fpm or below):
    a. Maximum Rate Velocity: 1500 fpm.
    b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.

c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10" sp w.g. at full air flow.
d. Pressure rating: 4" w.g.
e. Manufacturer: Ruskin #SD-37, Ruskin #SD-60, Greenheck #SMD-201, Pottorff #SD-141, Pottorff #SD-151, or equal by Nailor, Cesco or Air Balance.

5. High Velocity Applications (Greater than 1500 fpm):
   a. Maximum Rate Velocity: 4000 fpm.
   b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20" sp wg at full air flow.
   d. Pressure rating: 4" wg.
   e. Manufacturer: Ruskin #SD-50, Greenheck #SMD-401, or equal by Pottorff, Nailor, Cesco or Air Balance.

2.18 VARIABLE AIR VOLUME TERMINAL UNITS

A. Furnish and install variable volume zone boxes of the sizes and capacities shown on the Drawings.

B. The control assemblies shall be pressure independent and shall be able to be reset to any airflow between zero and maximum scheduled CFM. The valves shall be normally open. The differential static pressure of the basic assembly shall not exceed 0.25" w.g. for all sizes with inlet velocities of 2,000 fpm or less.

C. The air valve shall be galvanized steel or die cast aluminum; damper shafts shall operate in rustproof Delrin or equal, self-lubricating bearings. The air valve shall seat against durable gaskets and not exceed a 2% leakage rate per ARI standards.

D. The control device shall be designed to maintain consistent flow measurement regardless of inlet flow deflection. Angled duct inlets, at 90° or less to the control device, shall not alter the maximum or minimum factory setting by more than 10%. The assembly shall incorporate a multi-point averaging differential pressure sensor mounted on the inlet.

E. The cabinet assemblies shall be contained in a 22-gauge (minimum) galvanized steel box.

F. Cabinet shall be internally insulated with liner that prevents fibers from entering the air stream.

1. Insulation liner shall be 3/4" thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.
2. Insulation types include, but are not limited to, the following:
   a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
   b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.
   c. Elastomeric or polyimide foam insulation with acrylic polymer airstream coating.
   d. Natural (denim or recycled) fiber with bio based thermosetting resin mat fiber-free facing, foil facing or sheetmetal facing.
3. Refer to Section 230713 "Duct Insulation" for additional requirements.
4. Comply with ASTM E84, ASTM C1071, UL 723, UL 181, NFPA 90A and 90B, and UL Greenguard Low VOC certified.
5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).

6. Flame spread index: ASTM E84, less than 25.
7. Smoke developed index: ASTM E84, less than 50.

G. Fabricate and install 5 foot (minimum) acoustically lined sheet metal discharge plenum on all air terminal units. Refer to detail on drawings for more information. Discharge plenum shall be mounted downstream of reheat coils where applicable. Inside dimension of plenum shall be 2" larger in height and 4" larger in width than the outlet of the air terminal unit or reheat coil, whichever is greater. Refer to detail on plans for additional information. This is required for acoustic noise dissipation.

H. Electric Coil: Terminal manufacturer to factory install coil. Coil to be UL listed. They shall be housed in an attenuator section integral with the terminal with element grid recessed from unit discharge a minimum of 5" to prevent damage to elements during shipping. Elements shall be derated nickel chrome, supported by ceramic isolators a maximum of 3.5" apart, staggered for maximum thermal transfer and element life and balanced to ensure equal output per step. The integral control panel shall be housed in a NEMA 1 enclosure with hinged access door for access to all controls and safety device. Provide a primary automatic reset thermal cutout, a manual reset secondary thermal cutout, line fusing, mercury contactors per element, differential pressure airflow switch for proof of flow, and line terminal block. Coil shall be capable of operating under continuous duty at 120°F discharge temperature. Unit shall include an integral door interlock type disconnect switch which will not allow the access door to be opened while power is on. Coils 4 kw to 8 kw shall be 2 stage, 8 kw and larger shall be 3-stage. Coordinate final voltages with Div. 26.

I. Controls to be direct digital and connected to the BAS. Provide boxes without operator. Provide factory mounted low voltage transformer of sufficient capacity to power the DDC controls. Coordinate control with temperature Control Contractor. Provide factory mounted operator and thermostat control if not provided by Control Contractor.

J. Manufacturer: Titus ESV-3000, Nailor 3000 Price SDV, or equal.

2.19 DUCT SILENCERS

A. Sound traps shall be IAC Acoustics, Vibro-Acoustics, Aerosonics, United McGill, Pottorff, Ruskin, Nailor or equal. Sound traps shall be sized for a maximum air pressure drop and maximum air velocity as noted on schedule.

B. Materials

1. Outer casings of rectangular silencers shall be made of 22-gauge type #G-90 lock-former-quality galvanized steel.
2. Interior partitions for rectangular silencers shall be not less than 26-gauge type #G-90 galvanized lock-former-quality perforated steel.
3. Filler material shall be as indicated on the Schedules and as appropriate for the application:
   a. Standard fill: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof.
   b. Encapsulated fill for hospital or clean room applications: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate

voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior perforated baffles by means of a noncombustible, erosion resistant, factory-installed, acoustic stand-off. It shall not be acceptable to omit the acoustic stand-off and try to compensate for its absence by means of corrugated baffles.

c. Packless sound traps: No sound absorptive material of any kind is to be used in the silencers. The silencers shall attenuate air/gas transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.

d. "Green" fill alternate: Acoustic fill material shall be 100% environmentally friendly, and constructed of recycled natural fibers. Each fiber shall be treated with an EPA registered fungal inhibitor in order to prevent mold, mildew, fungi, and pest protection. The fill material must not contain any harmful chemicals, irritants, and/or volatile organic compounds (VOCs) in order to prevent off-gassing.

4. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E 84, NFPA Standard 255, or UL No. 723:
   a. Flame Spread Classification: 25
   b. Smoke Development Rating: 50

C. Construction

1. Units shall be constructed in accordance with the ASHRAE Guide recommendations for high pressure duct work. Seams shall be lock formed and mastic filled. Rectangular casing seams shall be in the corners of the silencer shell to provide maximum unit strength and rigidity. Interior partitions shall be fabricated from single-piece, margin-perforated sheets and shall have die-formed entrance and exit shapes so as to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator. Blunt noses or squared off partitions will not be accepted.
2. Attachment of the interior partitions to the casing shall be by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance. Interior partitions shall be additionally secured to the outer casing with welded nose clips at both ends of the sound attenuator.
3. Sound attenuating units shall not fail structurally when subjected to a differential air pressure of 8-inches water gauge from inside to outside the casing. Airtight construction shall be provided by use of a duct sealing compound on the jobsite material and labor furnished by the contractor.

D. Acoustic Performance

1. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM Specification E477-99. The test facility shall be NVLAP accredited for the ASTM E477-99 test standard. Data from a non-accredited laboratory will not be acceptable. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves, and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for FORWARD FLOW (air and noise in same direction) and REVERSE FLOW (air and noise in opposite directions) with airflow of at least 2000 fpm entering face

velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections:
a. Rectangular, inch: 24x24, 24x30, or 24x36, and
b. Tubular, inch: 12, 24, 36, and 48

E. Aerodynamic Performance

1. Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with ASTM specification E477-99 and applicable portions of ASME, AMCA, and ADC airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

PART 3 - EXECUTION

3.01 DUCTWORK GENERAL REQUIREMENTS

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:

1. All duct system appurtenances are to be the same material as ductwork including volume dampers and access panels.
2. Where duct joints are not connected using flanges or manufactured assemblies, provide sheet-metal screws equally spaces around the joint or equivalent fastening method as required by mechanical code and SMACNA HVAC Duct Construction Standards-Metal and Flexible. Where sheet-metal screws are utilized provide a minimum of three screws on round ductwork and minimum four screws on rectangular ductwork. Maximum spacing between screws shall not be greater than 12” on center.
3. Humidifier ductwork: Ductwork for humidifiers shall be constructed of 20-gauge stainless steel ductwork with longitudinal seam at top of horizontal runs and all joints sealed watertight. Duct length shall be as required by humidifier manufacturer, or as shown on drawings whichever is greater, to allow for full absorption of water vapor. This portion of duct shall include an integral drain pan and drain line connection.
4. Shower Rooms: Exhaust ductwork serving shower rooms or other wet areas shall be constructed of stainless steel or aluminum. Where shower room exhaust ducts connect to a general exhaust riser, the non-ferrous ductwork with sealed joints need only extend to point of connection to the general exhaust riser. Flexible duct connectors are not allow on horizontal ducts serving shower rooms.
5. Environmental exhaust ductwork serving domestic clothes dryers shall be constructed of metal and shall have smooth interior surface. Provide backdraft damper at discharge to atmosphere.
6. Underground Ducts:
   a. Install per manufacturer’s instructions.
   b. Install ductwork when outdoor temperatures are no lower than 20°F and do not exceed 95°F.
   c. Slope ducts at 1/8 inch per foot (minimum) to allow for drainage to an accessible low point for maintenance.
   d. All underground ductwork shall be pressure and leak tested prior to backfilling and prior to installation of concrete. Leak test report shall be submitted to Owner’s Representative for review and approval.
   e. Provide pea gravel or sand back fill all around ductwork.

7. Non-toxic and non-hazardous wet vapor exhaust, such as dishwasher, sterilizers, cart washers, and shower exhaust systems:
   a. Material: Type 304 or 316L stainless steel, minimum 24-gauge spiral or sheet metal ductwork with G90 zinc coating. Or, aluminum sheet minimum thickness of 0.86 mm. Type 304 or 316L stainless steel fittings.
   b. Joints: Welded but weld, T-25 flanged joints with external sealant all around, or swaged lap-joint with silicon caulk and stainless steel sheet metal screws.
   c. All accessories shall be stainless steel including dampers, damper hardware and turning vanes.

8. Hazardous/corrosive chemical exhaust, Radio-Isotope hood, and Bio-safety cabinet exhaust:
   a. Material: Type 316L stainless steel, minimum 18-gauge fully welded ductwork and fittings. Approved G90 galvanized steel may be used where required by local authority.
   b. Joints: TIG welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork not required.
   c. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc.
   d. Pressure testing: Refer to pressure classification and testing procedure table this specification section.

9. Chemical fume hood exhaust:
   a. Material: Type 316L stainless steel, minimum 18-gauge ductwork and fittings.
   b. Joints: TIG welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork not required.
   c. Flanges: Manufactured 309 stainless steel clamp and frame.
   d. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc.
   e. Pressure testing: Refer to pressure classification and testing procedure table this specification section.

10. Perchloric Acid Fume Hood Exhaust:
    a. Material: Type 316L stainless steel, minimum 10-gauge fully welded ductwork and fittings.
    b. Joints: TIG butt welded. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork required to achieve a smooth and slag free interior joint bead
    c. All accessories shall be 316 stainless steel.
    d. Pressure testing: refer to pressure classification and testing procedure table this specification section.

11. Magnetically or Electrically sensitive rooms, including MRI rooms:
    a. All ductwork, fittings, grilles/diffuser, screws, etc, shall be constructed of aluminum in and around magnetically/electrically sensitive rooms. Refer to all construction documents for location of these critical rooms.

3.02 DUCTWORK CONSTRUCTION AND SEALING CRITERIA

A. Leakage classification of ductwork shall conform to the minimum requirements of Table 3.1 and Table 3.2 (see below) based on procedures of "SMACNA HVAC Duct Construction Standards-Metal and Flexible" and "SMACNA HVAC Air Duct Leakage Test Manual" as follows:

TABLE 3.1 DUCT LEAKAGE CLASSIFICATION			
DUCT WORKING PRESSURE CLASS	AIR PRESSURE LESS THAN +/- 0.5"WC	AIR PRESSURE +/-0.5" TO +/-2.99"	AIR PRESSURE +/-3" TO +/-10" WC
SMACNA Seal Class	C	B	A
Sealing Applicable	Transverse joints	Transverse joints and longitudinal seams	Transverse joints longitudinal seams and all duct wall penetrations
LEAKAGE CLASS			
Rectangular sheet metal SMACNA Leakage Class	6	6	4
Round sheet metal SMACNA Leakage Class	6	4	2
Note: Duct sealant ranges and classification are generally more restrictive than SMACNA guidelines.			

B. Ductwork shall be constructed to SMACNA pressure class based on 150% of the maximum working pressure at connection to air handling unit, or better as specified herein. Unless called out otherwise on drawings the pressure classification of ductwork shall be as follows:

TABLE 3.2 DUCT CONSTRUCTION CLASSIFICATION				
DUCT SYSTEM	**LOCATION**	**WORKING PRESSURE (ESP FROM SCHEDULE)**	**BUILD TO SMACNA PRESSURE CLASS**	**BUILD TO SMACNA SEAL CLASS**
Outdoor air intake	From outdoor air intake to AHU	-1" wc	-2" wc	B
Low pressure supply air	Downstream of air terminal units to grilles, registers or diffusers.	+0.5"	+1" wc	B

TABLE 3.2
DUCT CONSTRUCTION CLASSIFICATION

DUCT SYSTEM	LOCATION	WORKING PRESSURE (ESP FROM SCHEDULE)	BUILD TO SMACNA PRESSURE CLASS	BUILD TO SMACNA SEAL CLASS
Low pressure supply air	From AHU to grilles, registers or diffusers.	+0.5 wc	+1″ wc	B
Low pressure return air	From return grilles to AHU	-0.5″ wc	-1″ wc	B
Transfer air	From grille to grille, or acoustic boots or "z" bends	-/+0.25″ wc	-/+0.5″ wc	C
Med pressure supply air	From AHU to air terminal units	+6″ wc	+10″ wc	A
Med pressure supply air	From AHU to air terminal units	+4″ wc	+6″ wc	A
Med pressure supply air	From AHU to air terminal units	+2″ wc	+3″ wc	A
Med pressure return air	From air terminal units to AHU	-3″ wc	-4″ wc	A
Med pressure return air	From air terminal units to AHU	-2″ wc	-3″ wc	B
Med pressure return air	From air terminal units to AHU	-1″ wc	-2″ wc	B
Relief air	From AHU to discharge at outdoors	+1″ wc	+2″ wc	B
General exhaust	From grille to exhaust fan	-1″ wc	-2″ wc	B
General exhaust	From exhaust fan to discharge at outdoors	+1″ wc	+2″ wc	B
Toilet/shower room exhaust	From grille to exhaust fan	-1″ wc	-2″ wc	B
Toilet/shower room exhaust	From exhaust fan to discharge at outdoors	+1″ wc	+2″ wc	B

3.03 DUCTWORK LEAKAGE TESTING

A. Refer to Section 230593 Testing, Adjusting and Balancing for air leakage testing requirements and procedures.

3.04 DUCTWORK SPECIALTIES INSTALLATION

A. Ductwork is generally diagrammatically indicated and shall be generally installed as indicated. Do not scale Drawings for exact location of ducts. Install ducts to best suit field conditions and cooperate with other trades. Do not penetrate Structural members without consent of Architect or Structural Engineer. Check with Structural drawings prior to locating any penetrations. Duct sizes are indicated as net inside dimensions on the Drawings. The indicated dimensions shall

be altered at the job site for the purpose of avoiding interferences and clearance difficulties to other dimensions producing the same air handling characteristics, provided such altered dimensions are approved by the Architect. Ducts shall be constructed in accordance with the latest edition of codes and standards identified in Part 1 and as shown on the Drawings.

1. Grilles, Registers and Diffusers: Install flush, squared, tightly sealed, and entirely covering sheet metal ductwork and gaskets. Thread sheet metal mounting screws tightly into sheet metal. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper only where individual duct mounted balancing dampers are specifically noted as not provided. Duct connections shall fit securely to necks or collars behind face area. Provide all necessary transition pieces and duct collars to make connections from ductwork to neck sizes. Where ducts connect directly to necks or collars provide a minimum straight duct section of two times the duct diameter to the last elbow. Where minimum straight duct sections are not physically possible provide sheet metal plenum sized for approximately 500 fpm air velocity with duct tapped directly to side of plenum. Where building walls, floors and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted and sealed to building structure.
2. Install turning vanes in all mitered elbows in all ducts, so that tips are parallel with the sides of the ducts. Tips of acoustical turning vanes on outside radius shall be flush with acoustical lining.
3. Provide flexible connections to completely isolate fans from direct contact with all sheet metal work.
4. Provide access doors, as required, for access to valves, controllers, dampers and humidifier dispersion tubes. Access doors required in Product Conveying Vapor/Moisture Ductwork (see applicable paragraph above) shall not be installed in the bottom of the duct or in a manner to allow leaks.
5. Volume Dampers: Provide manual volume dampers in all supply, return and exhaust branch and run-out ductwork to grilles, diffusers, registers, and other inlet and outlet openings to facilitate balancing of air distribution systems. These are to be provided as part of contract whether shown on plans or not. Where ceilings are not accessible, provide access door or remote damper regulator. Volume dampers must be installed immediately downstream of each duct takeoff.
6. Multi-Blade Control Dampers: Provide control dampers as shown on drawings. Coordinate with BAS system provider for control actuators.
7. Splitters and splitter dampers shall not be installed in medium or low pressure supply ductwork to VAV systems.
8. Clean and pretreat surfaces before application of sealant. Conform to the manufacturer's cleaning procedures. Install sealants in conformance with manufacturer's instructions.
9. Except where noted, vertical ducts or horizontal ductwork penetrating fire rated ceilings, roofs, walls and floors shall be fire separated with UL listed and labeled fire dampers installed per UL tested assembly including sleeves and retaining angles. Provide additional fire dampers indicated on the Drawings and as otherwise required by the IBC and building inspector. Provide approved firestopping between damper frames and firewalls. Install fire dampers in accordance with NFPA Standards, requirements of the State Fire Marshal, and applicable codes. Ensure that fire dampers are installed in the open position.
10. For penetration of fire rated partitions which meet the IBC Chapter Seven requirements of non-Group H occupancy penetration of tenant separation and corridor walls in buildings with fire sprinklers provide metal sleeves as follows: A minimum 12 inch-long (0.30 m) by 0.060-inch-thick (1.52 mm) steel sleeve shall be centered in each duct

opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 1-1/2" by 1-1/2" by 0.060-inch steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 screws. The annular space between the steel sleeve and wall opening shall be filled with rock wool batting on all sides.

B. Hangers and Supports: Securely fasten all ductwork to the building construction by means of hangers, supports, guides, anchors, and sway braces to maintain duct alignment, to prevent sagging, and to prevent noise and excessive strain on ductwork due to movement under operating conditions.

1. Maximum spacing between hangers shall not exceed ten (10) feet for rectangular sheet metal ductwork and twelve (12) feet for spiral round sheet metal ductwork. Provide hanger at each change in direction and at each branch takeoff. Refer to "SMACNA HVAC Duct Construction Standards Metal and Flexible" for additional requirements.
2. Provide duct supports within two (2) feet of each: duct elbow; connection to flexible ductwork; connection to terminal units; connection to fan coil units; connection to exhaust fans, connection to air handling units, and fire and/or smoke dampers.
3. Adequately mount and anchor all material and equipment as required. Include lateral bracing as required to prevent horizontal, seismic movement. Refer to IBC and Architectural and Structural Drawings for seismic requirements.
4. Do not support ductwork from other ducts, pipes, fans or any other pieces of equipment.
5. Powder driver fasteners shall not be used to support rectangular ducts larger than 40" maximum dimension. Powder driven fasteners shall not be allowed in existing facilities.
6. Support round duct, larger than 36", shall have two hangers at each support point.
7. Hangers and supports shall conform to SMACNA section "Hangers and Supports". Nail inserts, hangers and supports to formwork before slabs are poured. Cut off or remove nails, strap-ends and other projections, flush with concrete after forms are removed.
8. Support vertical ducts, passing through floors with two continuous angles screwed to the duct and bearing to the floor and conforming to SMACNA section "Riser Support-From Floor". Blocking or shimming ducts will not be permitted.

C. Other:

1. Fans: Align fans, motors, and drives. Install fans to render bearings accessible for lubrication without dismantling fans or ducts. Provide extended bearing oilers as required. Mount all fans on vibration isolators as specified.
2. Insulation: Properly and neatly apply insulation on all material and equipment and apparatus, as specified, including all fittings. Apply insulation over clean, dry surfaces, with adjoining sections firmly butted together and canvas smoothly pasted over. When vapor barriers are specified, install continuous overall external surfaces of the entire system.
3. Duct Sizing: Where duct sizes are not specifically shown on the plans or must be modified due to physical limitations, supply ducts may be sized at a maximum velocity of 1,500 fpm or 0.08" sp friction per 100 feet, whichever provides the larger duct, and return/exhaust/intake ducts may be sized at a maximum velocity of 1,000 fpm or 0.06" sp friction per 100 feet, whichever provides the larger duct. Refer to Basis of Design for further duct sizing criteria.
4. Humidifiers: Humidifier installation shall be approved by manufacturer and coordinated with all other systems. Condensate piping shall include p-traps as recommended by the humidifier manufacturer. Insulate exposed piping as required by the code.
5. Exterior Ductwork: Ductwork located and installed outside the building envelope, on roof, grade or other location exposed to weather, shall be constructed and sealed airtight and

watertight. The top of exterior ducts shall be cross-broken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.

6. Double Wall Ductwork: Insulated ductwork located and installed outside the building envelope may be constructed of two layers of galvanized sheetmetal encapsulating the insulation layer. The inner duct shall be constructed as the main carrier duct with gauge and fabrication as required per the SMACNA Duct Construction Standards and minimum 24-guage. The insulation layer shall be provided as required by the local energy code or Section 230713 Duct Insulation, whichever is greater. The outer sheetmetal layer shall be a non-pressurized layer, minimum 24-gauge, to encapsulate the insulation layer to prevent weather degradation and optimize the insulation effectiveness for the life of the building. The top layer shall be crossbroken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.
7. Access Floor Diffusers: The mounting ring for floor mounted diffusers are to be affixed to the floor tiles using a clamp insert or other method approved for use with the floor diffuser.

3.05 FLEXIBLE DUCTWORK INSTALLATION

A. Flexible insulated round ductwork connectors may be utilized where shown on the Drawings and for transitions between air handling equipment and rigid ductwork. A five (5) foot (maximum) length of flexible air duct shall be allowed to be used as an elbow at a terminal devices or air outlet/inlet, unless shown otherwise on the Drawings. No intermediate joints are allowed. Seal each end using two wraps of tape listed in accordance with UL 181B and marked 181B-FX, followed by a mechanical stainless steel screw operated drawband. Plastic drawbands are not allowed. Support duct to maintain smooth shape without sagging. All connections shall utilize welded conical tees, aluminum conical fitting, Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted. Damper regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

B. Flexible duct runouts to diffusers and grilles is limited to the following sizes:

1. 6” diameter: Up to 100 cfm
2. 8” diameter: Up to 200 cfm.
3. 10” diameter: Up to 360 cfm.
4. 12” diameter: Up to 600 cfm.
5. 14” diameter: Up to 900 cfm.

3.06 EXPANSION JOINTS

A. At a non-rated penetration through an expansion joint wall:

1. Provide insulated flexible ductwork through expansion joint. Flexible connector shall be no longer than five feet between segments of rigidly attached ductwork.

B. At a fire/smoke rated penetration through an expansion joint wall:

1. Provide required fire/smoke damper with sleeve through rated assembly as required by Building Code and manufacturer's instructions. Provide breakaway duct connections as required by manufacturer's listing. Ductwork bracing on either side of wall must not be rigid within ten feet of wall to allow for building movement. Seismic restraints must not be closer than ten feet of expansion joints on either side of wall. Following a building seismic/movement event the ductwork will need to be inspected and possibly reattached to the fire/smoke damper.

3.07 DUCT SILENCER REQUIREMENTS

A. Install the duct silencer per manufacturer's basic installation instruction.

B. Do not locate duct silencers within one duct diameter from fan discharge/intake openings, elbows, or takeoffs.

C. Where multiple duct silencer units are grouped together in parallel within the duct system they shall be sealed airtight at all joints.

3.08 FABRIC AIR DISPERSION SYSTEM

A. Clean each air handling unit and rigid ductwork prior to installing the fabric air dispersion duct system.

B. Temporary Closure: At ends of ducts which are not connected to equipment of distribution devices at time of ductwork installation, cover with fire retardant film or other covering which will keep the ductwork system clean until installation is completed.

C. If fabric air dispersion system becomes soiled during installation, these sections should be removed and cleaned following the manufacturer's standard terms of laundry.

3.09 DUCTWORK SEALANT METHODS

A. General

1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
2. All installation shall be in accordance with manufacturer's published recommendations.
3. Cleanliness:
    a. Before installing sealant, Surface must be dry and be free of dirt, oil, grease, and loose or foreign matter that could impair adhesion wipe ductwork to a visibly clean condition.
    b. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.

c. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
d. Follow the Advanced Level requirements as found in the SMACNA Duct Cleanliness for New Construction Guidelines.

B. Installation of Mastic/Sealant Duct System

1. One Part Sealant System:
   a. Apply one-part sealant system at a 20 to 30 wet mil thickness with a brush, putty knife; caulk gun or spray to duct joints, fasteners and seams. Tool, if necessary, caulk bead with putty knife or brush. Let dry per manufacturer data sheet of a minimum of 48 hours.

2. Or, One Part Spray Applied Sealant System:
   a. Use a manufacturer approved airless sprayer capable of application pressure up 2,000 psi spraying through a minimum 0.111 tip. Apply in a smooth application perpendicular to the substrate at a rate of 20 to 30 wet mils to joints, seams and duct wall penetrations per manufacturer's technical data sheet. Let dry per manufacturer data sheet of a minimum of 48 hours.

C. Installation of Mastic/Sealant Duct System with 10-Year Warranty

1. Installation of Rolled Sealant Tape over Mastic/Sealant:
   a. Cut desired length for each side of the ductwork; peel off release liner and center over joint, seam or penetration. The rolled sealant should completely cover the sealant. Use hand pressure to place the rolled sealant followed by a squeegee application. Lap tape end 2 inches (50 mm minimum). Squeegee rolled sealant to insure bond and complete adhesion to the duct. Instant adhesion requires precise positioning. Not re-positional. Four-Bolt flange requires applying corner pieces prior to applying the edge strips.

D. Field Quality Control

1. Allow duct sealant system to cure minimum 48 hours before pressure testing for the fluid applied Sealants. Rolled sealants can be tested immediately with duct leakage tester.
2. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.
3. Notify Owner's Representative a minimum of seven (7) calendar days in advance of leakage testing.
4. Leaks identified during ductwork air leakage testing shall be repaired by:
   a. Complete removal of the sealing materials.
   b. Thorough cleaning of the joint surfaces.
   c. Installation of multiple layers of sealing materials.

5. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

3.10 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.11 FIBERGLASS DUCTWORK INSTALLATION

A. Fiberglass ductboard may be utilized as an option to sheet metal ductwork in the following applications and as indicated on the drawings:

1. Return air transfer ducts between two adjacent rooms with maximum design static pressure in the following range: -0.5" w.g. to +0.5" w.g.

3.12 DUCT SMOKE DETECTORS

A. Duct mounted photoelectric smoke detector. One required for each heating or cooling system supplying air in excess of 2,000 cfm, for systems serving more than one occupancy type, and for control of each combination fire/smoke damper when not controlled by Division 26 area wide detection system.

B. Coordinate with Division 26 work and electrical installer for power to smoke detector. Detector shall be installed in the system in compliance with Chapter 6 of the Mechanical Code and NFPA-72. Provide 24-volt power supply option and/or 24-volt transformer as required to coordinate with Division 26.

C. Coordinate with controls installer to assure that detector shall shut down the air-moving equipment when smoke is detected and closes associated damper actuator(s). Sensor shall be selected to operate with air velocity rating from 100 to 4000 fpm. Provide with metal sampling tube. Provide remote test and reset station at ceiling or as otherwise indicated. Duct smoke detector shall be installed in the supply or return in compliance with the applicable mechanical or building code. Coordinate with Section 230900 and 230593 work.

D. Where return air risers serve two or more stories and serve any portion of a return air system having a design capacity greater than 15,000 cfm, smoke detectors shall be installed at each story. Duct smoke detectors shall be located upstream of the connection between the return air riser and any air ducts or plenum. Provide additional duct smoke detectors where required by NFPA-90A.

E. Provide additional duct smoke detectors in high rise buildings and I-2 Occupancies per the Section 907.2 of the Building Code with duct smoke detectors in the main return and exhaust air plenums of each air-conditioning system having a capacity greater than 2,000 cfm.

3.13 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPER INSTALLATION

A. Install per UL and manufacturer's installation requirements.

B. For buildings with no fire alarm system all fire/smoke dampers shall be interconnected with the HVAC unit's controls and duct smoke detectors. The detection of smoke at any fire/smoke damper shall stop for HVAC unit fans and close all fire/smoke dampers. A single test/reset station shall be capable or resetting all devices back to normal operation.

C. Smoke and fire/smoke dampers shall close upon activation of a listed smoke detector or detectors installed in accordance with Chapter 7 of the Building Code. Other than in mechanical smoke control systems, smoke and fire/smoke dampers shall be closed upon fan shutdown where local smoke detectors require a minimum velocity to operate. Coordinate with electrical installer for all work associated with smoke and fire/smoke damper wiring and smoke detector initiation.

D. Smoke dampers shall be installed in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment, including filters, from the remainder of the system on both the supply and return side, in order to restrict the circulation of smoke per NFPA 90A. Smoke dampers are not required where combination fire/smoke dampers are utilized in a smoke control system or where air handling systems serve only one floor. Refer to other exemptions as applicable per local AHJ.

3.14 CONTROL DAMPER INSTALLATION

A. Note that installation of control dampers is a part of the mechanical contractor's work regardless of whether they are specified in this section or as part of products to be selected by the Control Contractor.

B. When electric actuators are provided, dampers shall be installed to allow direct over the shaft mounting of actuators. No connecting rods and stand-off brackets shall be necessary.

C. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallellogramming), bowing, or other installation error.

D. Blades shall close completely. Leakage shall not exceed manufacturer's specifications at rated static.

E. Structural support shall be provided as necessary for all multi-section dampers.

F. Where blank-offs or structural supports obstruct duct or air passages, the decrease in free area shall not exceed 15% of the damper face area unless otherwise specified here or on plans.

G. No individual damper section may exceed 20 sq. ft.

H. Dampers shall be parallel blades style for outside air economizer to facilitate improved mixing of outside air and return air. Airflows shall be directed towards each other.

I. Where ducts penetrate an exterior surface install a Class I motorized damper at each outdoor air supply opening, exhaust opening, relief outlet, shaft vent and stairway vent, as required to comply with minimum requirements of the local Energy Code.

1. Dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the system served requires outdoor air or exhaust air or operates continuously or the dampers are opened to provide intentional economizer cooling.
2. Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

3.15 SEISMIC REQUIREMENTS

A. See Section 230549 for specific requirements.

B. All HVAC equipment and machinery shall be anchored to withstand forces generated by earthquake motions. As a minimum, equipment and equipment frames shall be designed to withstand a force of 100% of the weight of the equipment and frame acting at its center of gravity. Anchorage of the equipment and/or frame to the structure shall be for a force of four times gravity also acting at the center of gravity.

C. The seismic calculations shall be the responsibility of contractor.

D. 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-Seismic Restraint Manual: Guidelines for Mechanical Systems and ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) and longitudinal supports a maximum of 80 feet (24 m) on center.
2. Brace each change of direction longer than 12 feet (3.7 m).

E. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

G. Install cable restraints on ducts that are suspended with vibration isolators.

H. Install seismic-restraint devices using methods approved by the AHJ.

I. 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.

J. 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.

3.16 EQUIPMENT

A. Install equipment as shown on plans and in accordance with manufacturer's installation recommendations.

3.17 SUPPLY DIFFUSER AND REGISTER LOCATIONS

A. Coordinate location of supply outlets with ceiling mounted smoke detectors. Locate outlets or outlet distribution so as to prevent airflow from inhibiting the operation of smoke detectors. Locate ceiling outlets a minimum of 3'-0" from smoke detectors.

3.18 PAINTING

A. Where the interior surfaces of ductwork are visible through the blades of supply outlets, return inlets, and exhaust inlets - paint the interior visible surfaces with one coat of flat black paint.

B. Ductwork exposed on the roof or exterior to the building shall be painted. Coordinate with Division 9 for requirements.

3.19 FIELD QUALITY CONTROL

A. Do not insulate or conceal ductwork before inspection by Owner's Representative, Architect or Engineer. If ductwork is insulated and concealed prior this inspection the Contractor shall remove insulation and ceiling to permit inspection at no additional cost to the Owner. The Contractor shall replace the insulation and ceiling after final inspection at no additional cost to the Owner.

B. Ductwork Deflection Criteria:

1. Maximum inward and/or outward deflection at sheet metal panels and longitudinal joints shall be 3/4" under maximum static pressure operating conditions. Additional intermediate stiffening angles shall be installed where deflections exceed 3/4".
2. Maximum inward and/or outward deflection at sheet metal elbows and lateral joints shall be 1/4" under maximum static pressure operating conditions. Additional stiffening angles shall be installed where deflections exceed 1/4".

C. Acceptance of duct systems shall be contingent upon conformance with the requirements specified in Section 230593 "Testing, Adjusting and Balancing".

3.20 ADJUSTING AND CLEANING

A. Clean the inside of plenums, casings, enclosures, fans, and accessible ductwork before starting fans. Blowout coils and condensate piping with compressed air. Comb all coil fins that may be bent. Install a clean set of filters in each system prior to testing and balancing. Proceed with testing and balancing. All dampers shall be locked in place.

3.21 DUCT SEALING ALTERNATIVE

A. Occasionally a ducted system will experience leaks after the ductwork has been installed and sealed per one of the SMACNA duct sealant classifications. These leaks may not be identifiable until after ductwork has been installed and system air balancing and leakage testing has been engaged. At the contractor's option an alternative solution to sealing such leaks may include the use of a water based sealing agent that is introduced to the interior of the duct system.

1. Manufacturer: Aeroseal LLC or approved equal. Application must be performed by manufacturer approved provider.
2. Sealant must be UL 723 approved for smoke and flame spread.
3. Sealant must be UL 181 approved for humidity, mold growth, temperature, erosion and puncture resistance.

B. Duct Sealing Procedure:

1. Preparation:
    a. Inspect the entire duct shaft and horizontal plenums for major leakage sites (larger than 1/2" across).
    b. Mechanically clean duct shaft per NADCA (National Air Duct Cleaners Associations) standards if more than 1/8" of surface contaminants are visible on duct surfaces.
    c. Repair all major leakage sites using mastic and fiberglass mesh tape per SMACNA standards.
    d. Temporarily remove or protect all building controls and smoke detectors from aerosol particles as recommended by the Manufacturer.
    e. Temporarily disable fire alarms and notify appropriate authorities.
    f. Temporarily isolate air-moving equipment and block off air inlets and air outlets as recommended by the manufacturer.
    g. Protect occupied spaces from aerosol particles as recommended by the Manufacturer.
    h. Protect air-moving equipment, air inlets and outlets and other devices and appurtenances as recommended by the manufacturers.

2. Duct Sealing:
    a. Seal existing ductwork from the inside using automated aerosolized sealant injection as recommended by manufacturer or by manually caulking internally with sealant.
    b. Sealant must cure within 2 hours with no odor or VOC off-gasing thereafter.
    c. Sealant shall remain elastic (not harden rigidly) after curing.
    d. Sealant shall be deposited substantially at areas of leakage only, and shall not coat interior duct walls, duct lining material, dampers, or turning vanes.
    e. Seal all test holes using patching plates sealed with mastic.
    f. Repair or replace insulation to match existing.
    g. Seal all injection openings with duct access doors or replace ductwork to match existing.

3. Duct Reassembly and Cleanup:
   a. Reinstall building controls and smoke detectors.
   b. Enable fire alarms and notify appropriate authorities.
   c. Remove blocking, reinstall grills and registers, and enable air handling fans.
   d. Cleanup sealant residue that may have adhered to surfaces in occupied areas as recommended by the Manufacturer.
   e. All work shall be done in a substantial and workmanlike manner by factory-trained technicians.

4. Testing:
   a. Provide pre-sealing and post-sealing leakage profile reports indicating percentage reduction of duct leakage for both supply and return ductwork.
   b. Retest ductwork and document compliance with air leakage requirements as identified in section 230593 Testing, Adjusting and Balancing.

5. Warranty:
   a. The Contractor shall warrant that the aerosol sealant application will be free from defects for a period of 3 years from date of the sealing application. If defects should occur during this period, the Contractor shall repair or replace the defective duct seals, including the direct labor costs for performing the repair or replacement, at no additional cost to the Owner.

END OF SECTION 233113

SECTION 234100 - AIR FILTRATION

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. This Section includes factory fabricated air filter devices and media utilized to remove particulate matter and gaseous contaminants in HVAC applications.

B. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Air filters.
2. Filter racks.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 233113: Air Distribution

1.04 DEFINITIONS

A. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers

B. IEST: Institute of Environmental Sciences and Technology

C. UL: Underwriters Laboratories.

D. Atmospheric Dust Spot Efficiency – per ASHRAE Standard 52.1 – Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. Information deleted as this Standard was closed by ASHRAE in 2008.

E. DOP: Dioctyl Phthalate, a carcinogen that was part of the original military-defined process of testing HEPA filters, no longer used to evaluate filters. Where noted, HEPA/ULPA filters should be evaluated using polystyrene latex spheres (PSL).

F. HEPA: High-Efficiency Particulate Air filter, a filter with a factory confirmed efficiency of no less than 99.97% when evaluated on particles 0.3 microns in size.

G. ULPA: Ultra Low Penetration Air Filter, a filter with a factory confirmed efficiency of no less than 99.9995% when evaluated on particles 0.12 microns in size.

H. HEGA: High Efficiency Gas Adsorber, box-style filter with a removal rate on specified contaminants exceeding 95%.

I. MERV: Minimum Efficiency Reporting Value per ASHRAE Standard 52.2 - Method of Testing General Ventilation Air Cleaning Devices for Removal by Particle Size

J. MERV-A: A value from Appendix J in ASHRAE Standard 52.2 that is reflective of an air filters ability to maintain efficiency over time. The MERV-A should be equivalent to the respective MERV of the specified filter.

Std. 52.2 MERV	Approx. Standard 52.1 Results		Application Guidelines		
	Dust Spot Efficiency	Arrestance	Typical Air Filter/Cleaner Type	Typical Controlled Contaminant	Typical Applications and Limitations
20	n/a	n/a	**HEPA/ULPA Filters:** >99.999% efficiency on 0.10-0.20µm articles, IEST Type F	**<030µm Particle Size** Virus (unattached) Carbon Dust Sea Salt All combustion smoke Random progeny 99.99% efficient in capturing Viruses (unattached) per NASA TM-2016-218224	Cleanrooms Radioactive materials Pharmaceutical mfg. Carcinogenic materials Orthopedic surgery
19	n/a	n/a	>99.999% efficiency on 0.30µm particles, IEST Type D		
18	n/a	n/a	>99.99% efficiency on 0.30µm particles, IEST Type C		
17	n/a	n/a	>99.97% efficiency on 0.30µm particles, IEST Type A		
16	n/a	n/a	**Bag Filters** Non-supported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 inch) deep, 6 to 12 pockets. **Box Filters** Rigid Style cartridge filters 150 to 300 mm (6 to 12 inch) deep may use lofted (air laid) or paper (wet laid) media.	**0.30-1.0µm Particle Size** All bacteria Most tobacco smoke Droplet nuclei (sneeze) Cooking oil Most smoke Insecticide dust Copier toner Most Face powder Most paint pigments	Hospital inpatient care General surgery Superior commercial buildings
15	>95%	n/a			
14	90-95%	>98%			
13	80-90%	>98%			
12	70-75%	>95%	**Bag Filters** Non-supported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 inch) deep, 6 to 12 pockets. **Box Filters** Rigid Style cartridge filters 150 to 300 mm (6 to 12 inch) deep may use lofted (air laid) or paper (wet laid) media.	**1.0-3.0µm Particle Size** Legionella Humidifier dust Lead dust Milled flour Coal dust Auto emissions Nebulizer drops Welding fumes	Better commercial buildings Hospital laboratories
11	60-65%	>95%			
10	50-55%	>95%			
9	40-45%	>90%			
8	30-35%	>90%	**Pleated Filters Disposable**, extended surface, 25 to 100 mm (1 to 4 inch) thick with cotton-polyester blend media, cardboard frame. **Cartridge Filters** Graded density viscous coated cube or pocket filters, synthetic media **Throwaway Disposal** synthetic media panel filter.	**3.0-10.0µm Particle Size** Mold Spores Hair Spray Fabric protector Dusting aids Cement dust Pudding mix Powdered milk	Commercial buildings Better residential Industrial workplaces Paint booth inlet air
7	25-30%	>90%			
6	<20%	85-90%			
5	<20%	80-85%			

4 3 2 1	<20% <20% <20% <20%	70-80% 70-75% 65-70% <65%	**Throwaway Disposable** Fiberglass or synthetic panel fibers. **Washable** Aluminum mesh, latex coated animal hair, or foam rubber panel filter. **Electrostatic** Self charging (passive) woven polycarbonate panel filter.	**>10.0µm Particle Size** Pollen Spanish Moss Dust mites Sanding dust Spray paint dust Textile fibers Carpet fibers	Minimum filtration Residential Window air conditioners

1.05 QUALITY ASSURANCE

A. Codes and Standards: Provide filters conforming to the requirements of the latest addition of the following:

1. ANSI/AHRI-850: Performance Rating of Commercial and Industrial Air Filter Equipment.
2. UL-900: Standard for Safety Air Filter Units.
3. UL-586: Standard for High-Efficiency, Particulate, Air Filter Units.
4. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
5. NFPA-70: National Electrical Code.
6. NFPA-90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.
7. NFPA-90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
8. IEST-RP-CC001: HEPA and ULPA Filters.

B. Design Criteria

1. Air flow not to exceed rated capacity
2. Initial and final resistance not to exceed scheduled values.
3. Air filters shall be accessible for cleaning or replacement.

C. Manufacturer shall provide evidence of facility certification to ISO-9001:2008.

1.06 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final (with dirty filter allowance) pressure drop at rated airflow; efficiency and test method; UL classification; furnished specialties; and accessories for each model indicated. Manufacturers literature and sales drawings acceptable.

B. Shop Drawings: Include plans, evaluations, sections, and details to illustrate component assemblies and attachments.

C. Show filter holding mechanism assembly, dimensions, materials and methods of installation and sealing in drawings.

D. Include setting drawings, templates and requirements for installing anchor bolts and anchorages.

E. Operation and Maintenance Data: For each type of filter and filter holding mechanism to include in emergency, operation and maintenance manuals.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect all products against dirt, water, chemical, and mechanical damage. Do not install damaged products. Remove damaged materials from project site.

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

1.08 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel. This requirement excludes disposable filter media.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to the following (for HVAC Air Filters, Terminal HEPA Filter Modules, Adsorbers, Built-up Bank Holding Frames, Side-Access Housings and Bag-in/Bag-out Containment Housings):

1. Camfil (Farr)
2. American Air Filter International (Flanders, PrecisionAire)
3. Filtration Grouphttps://store.filtrationgroup.com/hvac/hvac-pleated-air-filters
4. Clarcor Air Filtration Products (AirGuard, ATI, Purolator)
5. Eco-Air

B. Air Filter Gages and Pressure Switches

1. Dwyer Instruments

C. Non-ionizing, polarized media electronic air cleaners

1. Dynamic Air Quality Solutions

2.02 CONSTRUCTION FILTERS – MERV-7

A. Air handling equipment shall not be operated without construction pre-filters in place and shall be medium efficiency, extended area, disposable type of the quantity and size indicated on the drawings.

B. The filter media shall have a minimum efficiency reporting value of MERV-7 when evaluated under the guidelines of ASHRAE Standard 52.2.

C. The filter media area and initial resistance shall be:

1.	For a 2" deep filter	10 pleats per linear foot	Maximum 0.28" w.g.
2.	For a 4" deep filter	9 pleats per linear foot	Maximum 0.20" w.g.

D. Manufacturer: Camfil #Aeropleat III or equal.

2.03 PREFILTERS AND SINGLE-STAGE PRIMARY FILTERS – EFFICIENCY MERV 8

A. Air handling equipment shall not to be operated without filters installed (ex: see construction filter section). Minimum efficiency during normal operation shall be no less than MERV 8.

B. The filter shall have a minimum efficiency reporting value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2.

C. Each filter shall consist of a cotton and synthetic blend media, a welded wire media support grid and a high wet-strength beverage board enclosing frame.

D. The filter media area and initial resistance shall be:

1.	For a 2" deep filter	15 pleats per linear foot	Maximum 0.31" w.g.
2.	For a 4" deep filter	11 pleats per linear foot	Maximum 0.27" w.g.

E. Manufacturer: Camfil #Farr 30/30 or equal.

2.04 SINGLE-STAGE 1" AND 2" PRIMARY FILTERS – EFFICIENCY MERV 13

A. The filter shall have a minimum efficiency reporting value of MERV 13 when evaluated under the guidelines of ASHRAE Standard 52.2. Final resistance of 1.0" w.g.

B. Each filter shall consist of a cotton and synthetic blend media, a welded wire media support grid and a high wet-strength beverage board enclosing frame.

C. The filter media area and initial resistance shall be:

1.	1" filter depth	15 pleats per linear foot	Initial Resistance 0.47" at 375 fpm.
2.	2" filter depth	15 pleats per linear foot	Initial Resistance 0.25" at 375 fpm.
3.	4" filter depth	12 pleats per linear foot	Initial Resistance 0.29" at 500 fpm.

D. Manufacturer: Filtration Group #Aerostar Green Pleat, or equal.

2.05 SECONDARY FILTERS – MINI-PLEAT 4" DEEP TYPE EFFICIENCY MERV 11, 13, OR 14 AS NOTED ON DRAWINGS

A. Air filters shall be 4" deep high efficiency ASHRAE box style filters consisting of mini-pleated wet laid fine fiber media, thermoplastic resin separators, frame to media adhesive and high wet

strength beverage board enclosing frame. Sizes shall be as noted on drawings or other supporting materials.

B. Filter media shall be of one continuous sheet of micro fine wet-laid glass mat filter media formed into uniformly spaced pleats and formed into a mini-pleat pack configuration. Thermoplastic pleat separators shall provide uniform media separation to promote uniform airflow throughout the media. The enclosing frame shall be of high wet strength beverage board which shall be bonded to the entire periphery of the media pack to prevent air bypass. The frame shall include integral diagonal support members to ensure maintained media spacing and pleat stability. The diagonal support members shall be bridge-engineered to prevent filter racking and ensure filter configuration integrity. Filter shall be bi-directional with regard to airflow.

C. The filter shall have a Minimum Efficiency Reporting Value of MERV-11, MERV-13 or MERV-14 as stated on the drawings.

D. The filter shall be capable of withstanding 5" w.g. without failure of the media pack.

E. Performance of the filter shall comply with the following minimum performance data based on a 24" by 24" by 4" filter tested at 2000 CFM.

F. Minimum Filter Requirements:

Efficiency	Initial Resistance (w.g.)	Media Area
MERV 11	0.33"	113 sq. ft. based upon 24" by 24" by 4 size
MERV 13	0.44"	113 sq. ft. based upon 24" by 24" by 4 size
MERV 14	0.60"	113 sq. ft. based upon 24" by 24" by 4 size

G. Manufacturer: Camfil #Opti-Pac or equal.

2.06 SECONDARY FILTERS – DEEP PLEAT 12" DEEP BOX-STYLE - EFFICIENCY MERV 11, 13, OR 14 AS NOTED ON DRAWINGS

A. Air filters shall be high-efficiency ASHRAE high lofted supported media disposable type assembled in a compact and secure enclosing frame. Sizes shall be as noted on drawings.

B. The filter media shall be of micro fine glass laminated to a reinforcing backing to form a uniform lofted media blanket. The media blanket shall be formed into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation. The media shall be mechanically and chemically bonded within the frame to prevent air bypass. The enclosing frame shall be constructed of corrosion resistant galvanized steel. Media support contour stabilizers shall be mechanically fastened to diagonal support members to create a rigid and durable filter enclosure. There shall be a minimum of four contour stabilizers on the air entering side and four on the air exiting side.

C. The filter shall have a Minimum Efficiency Reporting Value of MERV-9, MERV-11, MERV-13, or MERV-14 as stated on the drawings.

D. The filter shall be capable of withstanding 10" w.g. without failure of the media pack.

E. Performance of the filter shall comply with the following minimum filter performance data based on a 24" by 24" by 12" filter tested at 2000 CFM:

Efficiency	Initial Resistance (w.g.)	Media Area
MERV 9 & 9-A	0.36″	58 sq. ft. based upon 24″ by 24″ by 12 size
MERV 11 & 11-A	0.31″	53 sq. ft. based upon 24″ by 24″ by 12 size
MERV 13 & 13-A	0.41″	53 sq. ft. based upon 24″ by 24″ by 12 size
MERV 14 & 14-A	0.53″	53 sq. ft. based upon 24″ by 24″ by 12 size

F. Manufacturer: Camfil #Riga-Flo or equal.

2.07 SECONDARY FILTERS – DEEP PLEATED 12″ V-BANK STYLE PLEAT-IN-PLEAT BOX-STYLE - EFFICIENCY MERV 11, 13, OR 14 AS NOTED ON DRAWINGS

A. Air filters shall be high-efficiency ASHRAE pleat-in-pleat V-bank disposable type assembled in a compact and secure enclosing frame. Sizes shall be as noted on drawings or other supporting materials.

B. Filter media shall be of micro fine glass formed into uniformly spaced pleats separated by glass filament separators and formed into a mini-pleat pack design. Each mini-pleat pack shall be assembled into a V-bank configuration with an appropriate number of packs to obtain required pressure drop. The media packs shall be bonded to the inside periphery of the enclosing frame with a fire-retardant phosphorus-free sealant. The enclosing frame shall include modular injection-molded plastic channels bonded to the media pack to prevent air bypass. Injection-molded modular plastic supports shall be placed on the air entering and air exiting sides. The filter shall have a nominal 1″ header that is an integral component of the enclosing frame. Injection-molded rigid plastic end caps shall be bonded to the top and bottom of the enclosing structure to ensure a rigid and durable filter. A gasket shall be included on header-to-header sealing surfaces to eliminate air bypass between headered filters. Filter shall be bi-directional with regard to airflow.

C. The filter shall have a Minimum Efficiency Reporting Value of MERV-11, MERV-13, MERV-14, or MERV-16 as stated on the drawings.

D. Performance of the filter shall comply with the following minimum filter performance data based upon a 24″ by 24″ by 12″ deep filter tested at 2000 cfm:

Efficiency	Initial Resistance (w.g.)	Media Area
MERV 11 & 11-A	0.22″	200 sq. ft. based upon 24″ by 24″ by 12 size
MERV 13 & 13-A	0.27″	200 sq. ft. based upon 24″ by 24″ by 12 size
MERV 14 & 14-A	0.29″	200 sq. ft. based upon 24″ by 24″ by 12 size
MERV 16 & 16-A	0.64″	200 sq. ft. based upon 24″ by 24″ by 12 size

E. The filter shall be capable of withstanding 10″ w.g. without failure of the media pack.

F. Manufacturer: Camfil #Durafil or equal.

2.08 SECONDARY (OR SINGLE-STAGE) FILTERS – MULTI-POCKET HIGH EFFICIENCY MERV 11, 13, OR 14 AS NOTED ON DRAWINGS

A. Air filters shall be high efficiency ASHRAE extended surface pocket style filters consisting of high loft air laid micro fine glass media, a reinforced ABS plastic header, ABS plastic pocket retainers, and bonding agents to prevent air bypass and ensure leak free performance.

B. Filter media shall consist of high-density air laid lofted micro fine glass media that is chemically bonded to a synthetic micro mesh media support backing forming a lofted filter blanket.

C. Individual pockets shall contain a minimum of 40 stitching support points per square foot of media area. All stitching centers shall be sealed through the use of a foam based sealant that shall remain pliable throughout the life of the filter. The sides and ends of each pocket shall be sewn with a chain-link over lock stitch.

D. Pockets shall be formed into tapered pleats, supported by controlled media space stitching, to promote uniform airflow across the surface of the media. At any point, the sizes of the upstream and downstream passages shall be proportional to the volume of filtered air. The pockets shall also have a conical configuration to minimize contact with HVAC system components.

E. Support members shall include an ABS plastic header and ABS plastic pocket retainers. The header shall be joined to the media to prevent air bypass. Individual pocket retainers shall be attached to the header frame with anchor ports allowing for visual confirmation. Bypass between pockets shall be eliminated through a snap-to-seal pocket retainer that shall be an integral part of the two-piece header design. The frame shall form a rigid and durable support assembly.

F. The air exiting side of the air tunnels include a pocket flange to ensure pocket integrity throughout the life of the filter. A downstream pocket-to-pocket partition shall provide additional pocket separation to ensure full flow through the entire media area.

G. A filter-to-filter sealing gasket shall be installed on one of the vertical members of the filter header.

H. The filter shall have a Minimum Efficiency Reporting Value of MERV-11, MERV-13, MERV-14, or MERV-15 as stated on the drawings.

I. Performance of the filter shall comply with the following minimum filter performance data based upon a 24" by 24" by 22" deep 8-pocket filter tested at 2000 cfm:

Efficiency	Initial Resistance (w.g.)	Media Area
MERV 9 & 9-A	0.20"	58 sq. ft. based upon 24" by 24" by 22" size
MERV 11 & 11-A	0.28"	58 sq. ft. based upon 24" by 24" by 22" size
MERV 13 & 13-A	0.45"	58 sq. ft. based upon 24" by 24" by 22" size
MERV 14 & 14-A	0.68"	58 sq. ft. based upon 24" by 24" by 22" size

J. The manufacturer shall warranty that the filter shall be capable of withstanding 10.0" w.g. without failure of the filter.

K. Manufacturer: Camfil #Hi-Flo ES or equal.

2.09 UNIVERSAL ASHRAE GRADE HOLDING FRAMES

A. Filter holding frame shall be constructed of 16-gauge galvanized steel. The frame shall be assembled from two corner sections and welded to assure a rigid and durable frame assembly for built-up bank HVAC level application. Centering dimples shall be an integral part of the frame to assist in aligning final filter and pre-filter if applied.

B. Frame-to-frame installation holes shall be an integral part of the frame, two holes on each vertical and three holes on top and bottom. The top of the frame shall be identified with etching.

C. The frame shall include eight integral corrosion resistant compression tabs, four on each horizontal member, to facilitate filter installation without the use of tools or other fasteners.

D. A 3/4" filter sealing flange shall be an integral component of the holding frame. All corners shall be flush mitered.

E. A replaceable filter-to-frame sealing gasket shall be installed on the flange to prevent air bypass and ensure that the filter seats securely against the sealing flange.

F. Holding Frames shall be assembled to form built-up filter banks with the use of nuts and bolts and vertical support members as detailed on manufacturer provided drawings. (Refer to details of assembly and support drawings.)

G. Dow 732 Sealant shall be applied to the periphery of all holding frames prior to clamping, assembly and bolting.

H. Manufacturer: Camfil FastFrame or equal.

2.10 CONTAINMENT – BAG-IN/BAG-OUT HOUSINGS

A. Side-access bag-in/bag-out, gasket seal housing. The housing shall be adequately reinforced to withstand a negative or positive pressure of 15" water gage. Housing design and filter arrangement shall allow air to enter and exit housing without changing direction. The housing shall accommodate standard size filters that do not require any special attachments or devices to function properly in the housing. Sizes shall be noted on drawings.

B. Housing shall be constructed of 14-gauge and 11-gauge T-304 stainless steel. All pressure retaining joints and seams shall be continuously welded with no porosities. Joints and seams requiring intermittent welds, such as reinforcement members, shall be intermittently welded. Housing shall be free of burrs and sharp edges. All weld joints and seams that are a portion of any gasket setting surface (duct connection flanges and filter sealing surfaces), shall be ground smooth and flush with adjacent base metals. All welded joints and seams shall be wire brushed to remove heat discoloration. The housing shall be reinforced to withstand a positive or negative pressure of 15" w.g. The upstream and downstream ductwork connections shall have 1 1/2" outward-turned flanges.

C. The housing shall have a bagging ring around each filter access port that is sealed by a gasketed filter access door. The filter access door gasket shall be silicone and shall be replaceable, if necessary. The bagging ring shall have two (2) continuous formed raised ridges to secure the PVC change-out bag. The bagging ring shall be hemmed on the outer edge to prevent the change-out bag from tearing.

D. Ancillary hardware including filter clamping mechanism, door handles, door studs and labels shall be 300 series stainless steel. The threaded pivot blocks in the filter clamping mechanisms shall be of brass construction. Filter access door knobs shall be cast aluminum and designed to prevent galling of threads.

E. A filter clamping mechanism shall be operated by means of a standard wrench from outside the housing. The clamping mechanism shall include two pressure channel assemblies with eight springs per filter and exert a minimum filter sealing force of 1,400 pounds per full size filter, 1050 pounds per half size filter, and 700 pounds per quarter size filter. The force shall be applied as an even, uniform load along at least 80% of the top and bottom of each filter outer frame. The filter clamping mechanism adjustment penetration through the housing wall shall be sealed airtight.

F. One (1) manufactured PVC change-out bag shall be furnished with each filter access port. Change-out bags shall be 8-mil. thick with a yellow translucent, non-sticking, matte finish. It shall include a 1/4" diameter elastic shock cord hemmed into the opening of the bag so when stretched around the housing bagging ring flange, a secure fit is created. The bag shall include three (3) integral glove ports to assist in filter change-out. One (1) nylon security strap shall be included per filter access port to prevent the bag from sliding off the bagging flange during the change-out process. Design of components shall be such that all change-out operations shall be within the bag so there is a barrier between the worker and the filter at all times.

G. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX and AWS D9.1 Specification for Welding of Sheet Metal. All production welds shall be visually inspected by qualified personnel.

H. The filter housing shall be factory tested for filter fit, flatness of filter sealing surface and operation of filter clamping mechanism. The filter sealing surface and the complete assembly pressure boundary shall be leak tested by the pressure decay method as defined in ASME N510 Testing of Nuclear Air Cleaning Systems. The filter sealing surface shall be tested at +10" water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume. The overall system pressure boundary shall be leak tested at +15" water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume.

I. Filter bags shall be capable of continuous operating to temperature extremes of 0°F to 150°F.

J. Multi-wide housing shall be equipped with a filter removal rod to pull the filters to the change-out position. The removal rod shall operate from the inside of the filter change out bag.

K. Manufacturer: Camfil GB-series or equal.

2.11 BUBBLE-TIGHT ISOLATION DAMPER

A. Dampers shall be butterfly type consisting of circular blade, mounted to axle within formed flanged frame.

B. Frame shall be constructed of steel channel with a clean and smooth interior surface.

C. Blade shall be minimum 1/4-inch thick and be complete with full circumference silicone blade seal mechanically attached to blade with full circumference retainer ring. Adhesive seals are not acceptable.

D. The axle shall be supported in sealed, relubricable, ball bearings mounted outboard of frame and be complete with axle shaft seals. Damper shall be actuated by external hand wheel gear operator, where indicated as manual type on drawings. For dampers serving the Damper frame and blade shall be fabricated from hot rolled steel.

E. All parts not otherwise protected shall be given one coat of epoxy- polyamide coating.

F. Dampers shall be designed and tested for bubble-tight leakage performance at the specified design pressure.

G. Each damper shall be individually tested for leakage in conformance to AMCA Standard 500-D-98.

H. Provide electric damper motors where motorized damper control is indicated on drawings. Damper motors to be 120 volts. "Fast acting" electric damper motors are required and able to close damper in one (1) second. Electric rotary actuator to have high torque, integral single phase, reversible, capacitor run motors and equipped with factory set travel limit switches, and motor brake. Damper motor to have auxiliary contacts for digital I/O signal from building direct digital control system.

I. Manufacturer/model: Flanders #DBT-E-316/304-xx (sized to match duct diameter per drawings), Ruskin, Camfill, or equal.

PART 3 - EXECUTION

3.01 TEMPORARY AND CONSTRUCTION FILTERS

A. Provide temporary filters, pre-filters and high efficiency filters, for use in filter banks during the construction period. If excessive dust, dirt and debris are encountered during the construction period the contractor shall replace the temporary filters at no additional cost to the Owner. At no time during the construction period are systems to be operated without pre-filters and final filters in place.

B. The Contractor shall provide continuous maintenance of the temporary filters in all units during the entire construction, start-up, testing, and final acceptance activities. The Contractor shall provide additional temporary filters as necessary to facilitate completion of all start-up, testing and commissioning activities.

C. Contractor Option: Protect all 40% or higher efficient filters upstream of air handling units during construction with temporary blankets of 1/2" MERV-7 polyester or fiberglass filter media or 2" disposable panel filters, U.L. Class 2 listed. Remove prior to air balancing and prior to acceptance. Replace any dirty filters that were not adequately protected during construction.

3.02 FILTER FRAME INSTALLATION

A. Install filter banks and holding frames leak tight and structurally sound to eliminate air bypass.

B. Filter banks three filters high or higher: provide 3" wide 16-gauge galvanized or stainless steel stiffeners between each vertical row of filters. Caulk frames before installing. After installation caulk any gaps appearing at the leading edge of the holding frames. Use DAP "Butyl Gutter

and Lap Sealer." After erection of the filter bank and caulking, tape the joints between filter frames on the downstream side with aluminum foil duct tape.

C. HEPA filter frames over 6" deep do not require stiffeners, only taping and caulking. HEPA filter frames must be bolted together; welding will not be acceptable.

D. Framing modules require sealant and stiffening only between modules and around the periphery.

3.03 FILTER INSTALLATION AND EXECUTION

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. The appropriate fastener, as recommended by the manufactured, shall secure each filter at its corner with a minimum four (4) fasteners per filter.

D. Install filters in position to prevent passage of unfiltered air.

E. Install filter gage for each filter bank, including pre-filters, and final filters

F. Install filter gage static-pressure tips upstream and downstream of filters to measure pressure drop through the filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. One gage may be used where filters are mounted immediately adjacent without intervening clear space. Adjust and level inclined gages.

G. Coordinate filter installations with duct and air-handling unit installations.

H. Electrical wiring and connections are specified in Division 26 Specification Sections.

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

3.04 FIELD QUALITY CONTROL

A. Filter cartridges shall be capable of easily being loaded and unloaded through access doors in the housings or access sections.

3.05 START-UP PROCEDURE

A. No fan shall be operated unless all particulate filters as specified (except gas phase filters) are installed, along with temporary pre-filter media.

B. When the pressure drop of the temporary media reaches 0.5" W.G. during construction, replace it with the spare set. If not used, deliver the spare set to the owner at job completion.

C. Gas phase carbon trays shall not be installed until just prior to beneficial occupancy and all paint is dry and cleaning solvents are completely evaporated. Test and balance contractor shall allow for resistance of carbon trays in his work by simulating their resistance on the system.

3.06 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.

3.07 SPARE FILTERS

A. Furnish one new complete spare set of filter cartridges for each filter bank listed below on completion and acceptance of the work:

1. Medium and high efficient bag filters.
2. Medium and high efficient rigid filters.

B. Final air balancing shall be performed with clean filters in place. If temporary construction filters are clean, as determined by test and balance agency, these temporary filters may be used for final balancing. Install final spare sets of filters only if, and when, directed by Owner's Representative. If not installed, deliver to Owner's Representative in sealed carton.

C. Replace all panel filters which are not temporary pre-filters with a new set at job completion and furnish Owner's Representative with an additional set in sealed cartons.

D. Furnish owner with one set of spare trays loaded with carbon, if carbon housings or adsorbers are specified on this project.

END OF SECTION 234100

SECTION 236200 - CONDENSING UNITS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Condensing Unit
2. Controls and control connections
3. Electrical power connections
4. Roof mounting frame and base

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230700: Mechanical Insulation

D. Section 233113: Air Distribution

E. Section 237312: Custom Factory Air Handling Unit

F. Division 26: Electrical

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide packaged units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
   a. 99 - Standards Handbook
   b. 210 - Laboratory Methods of Testing Fans
   c. 300 - Reverberant Room Method for Sound Testing of Fans
   d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data

e. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 210/240 – Performance Rating of Unitary Air Conditioning & Air-Source Heat Pump Equipment
   b. 270 - Sound Rating of Outdoor Unitary Equipment
   c. 340/360 – Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 15 - Safety Code for Mechanical Refrigeration
   b. 193 – Method of Test for Determining the Air Leakage of HVAC Equipment. All systems that move less than 3,000 cfm shall comply with less than 1.4% cabinet leakage rate.

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of units, which have been listed and labeled by UL.
9. Minimum Efficiency: Minimum efficiencies shall meet or exceed the values listed in this specification.

1.05 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.06 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for packaged units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals; in accordance with requirements of Division 1.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design: Daikin Applied

2.02 GENERAL DESCRIPTION

A. Furnish as shown on plans, Condensing Unit(s) . Unit performance and electrical characteristics shall be per the job schedule.

B. Configuration: Fabricate as detailed on prints and drawings.

C. The complete unit shall be ETL listed.

D. Unit shall be completely factory assembled and shipped in one piece.

E. Unit to be shipped with a nitrogen holding charge only.

F. The unit shall undergo an operational test prior to shipment. The factory test shall include a refrigeration circuit check test, a unit safety control system operations checkout, and a final unit inspection.

G. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

H. Performance: All scheduled capacities and face areas are the minimum accepted value. All scheduled amps, KW, and HP are maximum accepted values that allow scheduled capacity to be met.

2.03 CABINET

A. Exterior surfaces shall be constructed of painted galvanized steel, for aesthetics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16" at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

B. The unit base frame shall be constructed of 15 gauge pre-painted galvanized steel.

C. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

2.04 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be number and color coded and labeled according to the electrical diagram provided for easy identification.

B. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch circuit short circuit protection, 115 volt control circuit transformer and fuse, system switches, and a high temperature sensor. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Knockouts shall be provided in the side of the main control panels for field wiring entrance.

C. All 115-600 volt internal and external wiring between control boxes and components shall be protected from damage by raceways or liquid tight conduit.

D. The receptacle shall be powered by a field supplied 115V source.

E. Single terminal block shall be provided for connecting electrical power at the unit.

F. Unit SCCR rating to be 10 kAIC.

G. Unit shall be provided with a 24 volt transformer and terminal strip for field supplied controls.

2.05 CONDENSING SECTION

A. Air Cooled Condenser

1. The condensing section shall be open on the sides and bottom to provide access and to allow airflow through the coils. Condenser coils shall be multi-row and fabricated from cast aluminum micro-channel coils. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils are to be recessed so that the cabinet provides built in hail protection.
2. The fan casing or discharge attenuation shroud shall be made of heavy gauge steel with spun flanges and welded seams. Condenser fans shall consist of high pressure die cast aluminum airfoil blades, hub and clamp plate. The finish of the fan assembly shall consist of high pressure cleaning, application of one coat of primer and one coat of enamel paint. The fan RPM shall not exceed to allow 850 for quieter operation. All motors are totally enclosed air over design with a 1.15 service factor, Class F insulation with Class B rise, and 100,000 hour L10 bearings.
3. Units shall have at least one head pressure sensing condenser fan controlled to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 45º F ambient. SpeedTrol™ condenser fan speed control shall be added to the last fan off on each refrigeration circuit to provide cooling operation to ambient temperatures down to 0° F. Fan speed control shall be field adjustable (15 ton and larger condensing units)

B. Refrigeration Circuit. Provide two independent circuits with at least one digital scroll on one circuit for unit greater than 15 tons

C. Hot gas bypass capped T shall be factory installed on the discharge line of refrigerant circuits.

D. Provide quiet condensing unit fans consisting of airfoil blades with serrated trailing edges and special blade tips to break up turbulence and noise (unit 15 tons and larger). Provide compressor sound blankets.

E. Provide sesmic spring vibartion isolators rails for condensing units.

2.06 CONTROLS

A. Refrigeration capacity control shall be accomplished by the modulation of the digital scroll compressor and staging of fixed compressor(s). Unit shall be equipped with a 120V terminal strip for field supplied and installed controls (units at or over 15 tons). On/off compressor control (units under 15 tons)

2.07 WARRANTY

A. The manufacturer shall provide 12 month parts only warranty. Defective parts will be repaired or replaced during the warranty period at no charge. The warranty period shall commence at start up, or 6 months after shipment, which ever occurs first.

2.08 SOUND

CU-1

Sound							
Casing Radiated Sound Power (db)							
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
0	83	77	80	82	79	74	67

CU-2

Sound							
Casing Radiated Sound Power (db)							
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
0	91	81	82	83	79	74	70

CU-3

Sound
Casing Radiated Sound Power (db)

Total Average Sound Power: 88dB

CU-4A/4B

Sound							
Casing Radiated Sound Power (db)							
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
0	86	80	83	85	83	77	71

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instruction.

3.02 EXAMINATION

A. Verify that mounting surface, e.g. roof, is ready to receive work.

B. Verify that proper power supply is available.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide layout drawings of units, locations and power requirements to electrical installer.

C. Install minimum 30% efficiency air filters in unit during installation phase. Do not operate the unit without filters in place.

D. Mount rooftop unit on:

1. Seismically restrained spring vibration isolation curb. Install with top surface of roof mounting frame level.
2. Or, factory built roof mounting frame where vibration will not be perceptible to occupants. Install with top surface of roof mounting frame level.

E. Install 3" flexible duct connection at inlets and outlets of units.

F. Install condensate drain piping and traps in accordance with manufacturer's instructions, per local code and as shown on the drawings.

1. Install manufacturer provided condensate "air-trap" where provided with each unit. Install trap per manufacturer's instructions and install condensate piping as required by local code.

G. Control installers shall install thermostat and all wiring associated with control signals into the units.

H. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

I. Install a new set of filters prior to final air balance and substantial completion.

3.04 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the job site.

END OF SECTION 236200

SECTION 237312 – CUSTOM FACTORY AIR HANDLING UNITS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SUMMARY

A. Section Includes:

1. Variable-air-volume, multizone air-handling units. SF-1, SF-2, SF-3, SF-4a,4b

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230902: Variable Frequency Drives (VFD)

D. Section 233113: Air Distribution

E. Section 234100: Air Filtration

F. Division 26: Electrical

1.04 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 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/100, minimum, where "L" is the unsupported span length within completed casings.

C. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
   a. 99 - Standards Handbook
   a. 210 - Laboratory Methods of Testing Fans [Unit shall bear AMCA Certified Rating Seal]
   b. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
   b. 320 - Laboratory Methods of Sound Testing of Fans Using Sound Intensity
   c. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   d. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
   b. 430 - Central-Station Air-Handling Units

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 15 - Safety Code for Mechanical Refrigeration

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.
9. Units shall be listed and labeled by either UL or ETL for air handler construction.

1.06 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.07 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing

1. Dimensions and weights
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fan including:
    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.
    e. Fan assembly vibration and balance test report.
4. Certified coil-performance ratings with system operating conditions indicated.
5. Retain both subparagraphs below if items are furnished as parts of air-handling units.
6. Dampers, including housings, linkages, and operators.
7. Filters with performance characteristics.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.08 INFORMATIONAL SUBMITTALS

A. 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.

B. Source quality-control reports.

C. Field quality-control reports.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect unit against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.11 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. BASX Solutions, Daikin, Nortek Air Solutions (Governair, Huntair, Venmar, Temtrol, Mammoth), , By listing various manufacturers does imply that their standard construction is approved or that they are equal. All manufacturers must meet, or exceed, minimum requirements of these specifications and all other standard or optional features provided by the scheduled basis of design air handler.

2.02 GENERAL

A. Any exceptions to the specifications must be clearly defined in the submittal process. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Fabricate draw-thru or blow-thru type air handling units suitable for the scheduled air pressure operation as indicated.

C. Fabricate units with the following features: fan sections as noted; coil section(smixing section; filter section(s); access section(s); discharge plenum; variable frequency drives; dampers;. Fabricate unit in split sections for field assembly if necessary.

D. Fans shall be selected for variable volume operation. The scheduled fan arrangement and unit configuration is the basis of selection. Alternate configurations which are equal or smaller in size and weight, energy and acoustic performance will be considered. Include information indicating pertinent differences, either positive or negative, to base design indicated on documents. Unit component face velocity to remain as designed to conserve motor horsepower. The mechanical contractor and supplier shall bear all costs for redesign of mechanical, plumbing, electrical, structural, architectural and controls that may be associated with the revised configuration. Provide analysis of unit power consumption for code compliance.

E. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified.

F. All major components used to assemble air handling units with the exception of electrical devices, drives, bearings and controls shall be manufactured by the air handler manufacturer.

G. Motors shall be inverter duty NEMA MG-1 premium efficiency TEFC type. All wiring shall be routed to a single external junction box for each fan section.

H. Filter section shall include space for face load or side access slide-in filters with 2" or 4” pre-filters and 22" bag type final filters with an average efficiency of 85% per ASHRAE Standard 52-76 test.

2.03 UNIT CASING

A. Walls and roofs shall be constructed of 16-gauge, G90 galvanized steel 2” thick panels. The inner wall shall be a minimum of 22-gauge, solid galvanized steel in all sections. The wall panels shall be insulated with 2", 3.0 lbs/cu. ft rigid neoprene coated insulation. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer. Wall seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.

2.04 BASE CONSTRUCTION

A. Units shall be constructed from structural steel C-channel around the perimeter of the unit with intermediate channel, angle or tube supports.

1. Channel bases shall be sized as a function of air handling length as follows:

AHU LENGTH	MINIMUM CHANNEL SIZE	
11′ to 30′	6″ x 2″	(8.2 lbs/Lin.Ft.)

B. Floor shall be flat, reinforced from below, 16 ga G-90 solid metal. The base shall be provided with lifting lugs, a minimum four per unit section. The base shall be insulated tight to the floor with 4", 3.0 lbs/cu. ft fiberglass insulation. The insulation is to be protected with 22-gauge solid galvanized steel liner if the unit floor is exposed in a suspended application. Floors that "oil can" are not acceptable.

C. Floor insulation shall be installed beneath the floor panels in the same manner as the wall and ceiling insulation.

D. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
2. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
3. Depth: A minimum of 2 inches (50 mm) deep.
4. Integral part of floor plating
5. Single-wall 16-gauge, 304 stainless-steel sheet.
6. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on pan. Outlet diameter shall meet minimum sizing requirement of applicable mechanical code.
7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
8. The manufacturer shall provide auxiliary drains in mixing and OSA intake sections.
9. All drain connections on floor mounted air handling units shall terminate at the side of the unit.

E. Maximum base deflection shall be 1/4" on 20-foot unsupported span.

2.05 INSPECTION AND ACCESS PANELS AND ACCESS DOORS

A. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.

B. Inspection and Access Panels:

1. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.

2. Gasket: Neoprene, applied around entire perimeters of panel frames.
3. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

C. Access Doors:

1. Hinges: A minimum of two ball-bearing hinges and two roller cam-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
2. Gasket: Neoprene, applied around entire perimeters of panel frames.
3. Size: The minimum door clearance shall not be less than 19”x 70" (where unit height permits) and shall be large enough to allow the largest assembled internal compound to be removed through the doorway. Internal components must have a door of minimum width to remove the assembled components. Vestibule doors to the exterior shall be 42”x70” (where unit height permits).

D. Locations and Applications:

1. Verify that the sections listed below are large enough for panels and doors. Verify applicability with listed manufacturers.
2. Fan Section: Doors and inspection and access panels.
3. Access Section: Doors.
4. Coil Section: Inspection and access panel.
5. Damper Section: Doors.
6. Filter Section: Doors large enough to allow periodic removal and installation of filters.
7. Mixing Section: Doors.

2.06 FAN, DRIVE, AND MOTOR SECTION

A. All fans shall be tested in accordance with AMCA Standard 210-70 Test Code for Air Moving Devices. Fans shall bear the AMCA sticker for both air and sound performance.

B. 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 steel with keyway. Ship with a protective coating of lubricating oil. Hollow shafts are unacceptable.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range. The critical speed will be based on the top of the speed range for the fans’ AMCA class. The lateral static deflection shall not exceed 0.003” per foot of the length of the shaft.

2. Fan assembly shall be balanced per ISO standard G6.3 with a copy of the balance test data for this project with deflection and critical speed of the shat and wheel submitted to the engineer

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

1. Arrangement #4 direct drive fans or AMCA Arrangement #1 either horizontal or vertical as shown on plans and drawings. 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. The fan inlet on plenum fans shall be isolated from the cabinet by means of a neoprene-coated flexible connection. Plenum fans shall be provided with spring-style thrust restraints.

2. Each fan shall be sized to perform as indicated on the equipment schedule. The wheel diameter shall not be less than that shown on the equipment schedule. The fan shall be constructed to AMCA Standards for the Class Rating as indicated on the Equipment Schedule.

D. Internal Vibration Isolation and Seismic Control:

1. Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection as stated on the drawings.
2. 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 when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
3. Fan Assembly Testing:
    a. Following assembly, the fan balance shall be tested using an electronic balance analyzer with tunable filter and stroboscope.
    b. Direct drive fan wheels shall be factory dynamically balanced and shall meet or exceed guidelines in AMCA 204-96 for Balance Quality and Vibration Levels for Fan Application Category BV-5. Following fan assembly, the complete spring isolated fan assembly shall be tested using an electronic balance analyzer with tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 Axial). The maximum allowable velocity shall not exceed 0.125 inches per second peak amplitude (filter in) on any of 5 readings and shall not exceed .5 mils @ 1170 rpm.
    c. A copy of the Vibration test report (Vibration Nomograph) shall be provided with the Operation and Maintenance Manual upon request. The fan assembly shall also be vibration tested at design RPM with the spring isolators at the specified deflection, with the tunable filter utilized and frequencies from 500 cpm to 50,000 cpm shall be scanned to detect misalignment, bearing defects, mechanical looseness or foundation weakness. A copy of the balance test data for this project showing calculations for deflection and critical speed of the shaft and wheel assembly shall be submitted for review.

E. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG1.
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 electrical Sections.
5. Mount unit-mounted disconnect switches on exterior of unit.

2.07 COILS

A. Coils shall be designed with counter flow design.

B. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing to be accessible for service and can be removed from the unit through the side. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410-81.

C. Coils shall be fully enclosed within casing and mounted on primed and painted angle iron racks manufactured to allow coils to slide out individually. Cooling coil racks shall be primed with zinc rich chromate primer. Racks to be designed to allow coil removal from the face of the coil rack. All coils to be removable from either side of the unit by easily removable end panels. End panels that open to coil header and return bend section shall be installed with drive screws and nut-serts to allow access to header and return bend sections for coil inspection without disruption to unit air seal. Individual end panels to be supplied for each coil on the supply and return side of the cabinet to allow single coil piping breakdown for coil removal.

D. Coil penetrations through cabinet shall be grommeted, sealed airtight by a double escutcheon plate on the exterior of the casing. The escutcheon plate shall have a rolled collar around the pipe opening to protect the pipe and be equipped with an "O" ring rubber gasket between the collar and the pipe to prevent chaffing and provide an air tight seal around the opening. All supply and return connections shall be plainly and permanently marked

E. Both ends of the coil to be sealed off from the main air stream by full height blank-offs on both the entering-air and leaving-air sides. Blank-offs to be the same material as the coil casing. Headers and return bends to be further insulated with a closed cell neoprene gasket the full height and width of the coil casing to reduce condensation.

F. Drain pans shall be continuously welded type 304 stainless steel. Intermediate drain pans shall be interconnected with 1 in. stainless steel drain lines. Drain pans shall be sloped and fully drainable.

G. All coils shall be fabricated of 5/8" O.D. seamless copper tubing of 0.020 wall thickness minimum mechanically expanded into aluminum fins of 0.008 minimum thickness. All return bends shall be 0.035 copper minimum. Headers shall be of seamless copper. Supply and return connections on each coil shall be raised/lowered a minimum 6" from the bottom/top of the coil to allow room for piping connection hookup between stacked coils, coils near floors and coils near roofs. Each coil shall be provided with capped vent and drain connections extended to the exterior of the cabinet. All coils shall be fully drained with no trapped tubes. Coil casing to be 304 stainless steel for cooling coils and 16-gauge galvanized for heating coils.

H. Coils shall be hydrostatically tested at 400 psi, and shall be suitable for working pressures and temperature up to 200 psi and 22°F.

I. Pipe connections shall be on the same end, and shall be threaded. On units with split coils, extend coil pipe connections from coil header through unit side casing using specified pipe material.

J. Coils indicated as being cleanable shall have either a cleanout plug for each tube or shall have a gasketed removable header cover.

K. Coils for direct expansion refrigerant applications connected to multiple compressors shall be full face intertwined type.

2.08 HEATING SECTION (SF-3, SF4A, 4B):

A. Gas Heating Section:

1. Induced draft combustion type with intermittent direct spark ignition system and redundant main gas valve.
2. Heat exchanger: SS
3. All gas piping shall enter the unit cabinet at a single location.
4. Modulating gas valve with high turndown. 20:1

2.09 FILTERS

A. Provide pre-filters and front loading final filters. Pre-filters to be 2”MERV 8 and final filter to be 12” MERV13.

B. Filter Gauges

1. The manufacturer shall provide a DWYER (0-2 inch, 0-500 Pa) magnehelic gauge.
2. Magnehelic gauges shall be accurate to +/- 2% of full range.
3. One gauge shall be provided for each type of filter in filter bank.
4. Gauges shall be recessed into the cabinet casing with a weather cover.

2.10 FINISH

A. Factory Applied Finish for Steel and Galvanized-Steel Casings:

1. Casing Coating: Epoxy, Phenolic, Hot-dip galvanized, or Powder-baked enamel.

2.11 ALUMINUM AIRFOIL DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 5 percent of air quantity at 2000 fpm face velocity through damper and 3” wg (1000 Pa) pressure differential.

B. Aluminum airfoil frames and blades shall be a minimum of 12 gauge extruded aluminum. Blades shall be of a single unit airfoil design 6" wide.

C. Frames shall be extruded aluminum channel with grooved inserts for vinyl seals. Standard frames shall be 2" x 4" x 5/8" on the linkage side, 1" x 4" x 1" on the other 3 sides.

D. Pivot rods shall be 7/8" hexagon extruded aluminum interlocking into the blade section. Bearings shall be of a double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into the frame to prevent the outer bearing from rotating.

E. The bearing shall be designed so there are no metal-to-metal or metal-to-bearing riding surfaces. The interconnecting linkage shall have a separate Celcon bearing to eliminate friction inside the linkage.

F. Blade linkage hardware shall be installed in a frame outside the airstream. All hardware shall be of non-corrosive, reinforced cadmium plated steel.

G. Multiple damper motors are to be used rather than jack shaft assemblies.

H. Dampers shall be Ruskin #CD50, T.A. Morrison #1000, or equivalent.

2.12 SOUND POWER LEVELS

A. Air handling unit sound power levels shall be submitted for review. Sound power data shall be given at the supply connections and return connections in addition to radiated sound power from the cabinet. Raw fan sound power data shall be derived from testing on the identical fans as used in the units. Data extrapolated from different fans is not acceptable.

B. Attenuation assumed for cabinet configuration, type of insulation, opening location and sizes shall be verified through actual test measurements. All measurements shall be performed in an AMCA certified laboratory in accordance with AMCA standard 300 of ASHRAE 12.12. These test reports will be submitted to the Owner's Representative before units ship from the factory.

2.13 VARIABLE FREQUENCY DRIVES

A. Both supply and return fans are to be powered by variable frequency drives . See Section 230902 for additional requirements.

2.14 FLOW MEASURING PROVISIONS

2.15 ELECTRICAL

A. Each fan motor shall be wired to its respective VFD provided by fan manufacturer integral to unit. See Section 230902 and 2.1, G above for requirements.

B. All wiring shall be 6600 volt rated type XLPE, RW90 stranded copper, enclosed in conduit run internal to the unit. All junction boxes shall be CSA approved. Three phase loads to be color coded for phase matching.

C. All unit VFD's shall be wired to a surface or recessed mounted vestibule electrical panel for a single point three phase power connection provided by Division 26. Control panel shall be NEMA Type 3R enclosure with a single hinged access door. The control panel shall include:

1. Non-fused main disconnect switch, lockable in the off position
2. Dual element fuses
3. Distribution block

D. All wiring shall be numbered, and all remote connection terminals and components in the control panel shall be identified by tag suitable attached. Wiring diagram shall be provided for each unit showing all components, wire number and remote connection terminals.

E. Electrical wiring for lighting and power supply to fan motors shall be run in separate conduits internal to the unit. No external conduit runs are permitted. If the unit requires section splits, junction boxes shall be furnished at each section to allow the electrical contractor to make final connections in the field. Wiring to be clearly labeled at junction points to facilitate reconnection. Air handler manufacturer shall allow a minimum 1.5" clearance above the entire

width of each interior bulk headers (coils, filters, fan blank-off, etc.) for field-wiring of any 110v or 24v runs internally to the unit as required by the controls contractor and reduce the number penetrations of the exterior panels.

F. All electrical wiring and components shall be installed to conform to NEC and UL listing requirements. Provide a UL or ETL listing and label for the entire air handler.

2.16 ROOF CURB

A. Provide roofcurb to match existing unit curb dimensions. Roof curb to be a seismically calculated plenum type curb. Existing ductwork and roof penetrations will not be modified in the scope of this project.

2.17 SOUND POWER LEVELS

A. Air handling unit sound power levels shall be submitted for review. Sound power data shall be given at the outlet connections and inlet connections in addition to cabinet radiated sound power. Raw fan sound power data shall be derived from testing on the identical fans as used in the units. Data extrapolated from different fans is not acceptable.

B. Attenuation assumed for cabinet configuration, type of insulation, opening location and sizes shall be verified through actual test measurements. Sound power data is tested at the factory by an acoustical engineer in complete accordance with ARI 260-2001, "Sound Rating of Ducted Air Moving and Conditioning Equipment". These test reports will be submitted to the Architect before units ship from the factory.

C. When operating at the maximum design capacities, the tested sound power values shall not exceed the values scheduled in the following table.

Table 1: Maximum Allowable Sound Power Values

SF-1

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
Return Opening	79	81	86	82	75	73	70	63	83	89
Exhaust Opening	79	82	87	86	81	79	77	71	88	91
Casing Radiated	69	64	64	58	48	41	37	29	59	71

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
OSA Opening	82	85	93	87	78	74	71	67	88	95
Supply Opening	85	88	93	91	85	80	78	75	92	97
Casing Radiated	75	70	70	63	52	42	38	33	64	77

SF-2

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
Return Opening	81	92	96	83	83	82	78	70	91	98
Exhaust Opening	87	92	94	91	88	87	85	77	94	99
Casing Radiated	77	74	71	63	55	49	45	35	66	80

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
OSA Opening	84	87	100	91	82	81	79	73	93	101
Supply Opening	91	93	96	95	91	87	85	80	97	101
Casing Radiated	81	75	73	67	58	49	45	38	68	83

SF-3

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
Return Opening	77	86	83	76	74	75	78	79	84	89
Exhaust Opening	79	81	83	81	76	79	75	82	86	89
Casing Radiated	67	68	60	48	41	37	38	37	56	71

Air Handler Sound Power Projection

Octave Band Frequency (Hz)	63	125	250	500	1k	2k	4k	8k	LwA	Lw
OSA Opening	85	85	92	78	70	63	60	64	84	94
Supply Opening	84	87	92	83	76	69	67	63	86	94
Casing Radiated	74	69	69	55	43	31	27	21	62	76

SF-4

Sound

Sound Power (db)

Frequency	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Inlet	85	86	81	79	78	72	64	57
Discharge	80	78	72	67	64	58	50	42

PART 3 - EXECUTION

3.01 EXAMINATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work. Provide a layout drawing of air handler and fan locations to electrical installer.

C. 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.

D. Examine roughing-in for piping systems and electrical services to verify actual locations of connections before installation.

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

3.02 INSTALLATION

A. Air Handler Mounting:

1. Base Mounted: Install air-handling units on equipment base as described and specified elsewhere
   a. Concrete: Comply with requirements for equipment bases and foundations specified in Division 03.
   b. If return fans are configured to drawing inlet air from a raised curb, curb access must be provided for field installation and service of measuring devices and smoke detectors.

2. Vibration Isolators: Comply with requirements of 230548 Vibration Isolation.
3. Seismic Restraints: Comply with requirements for 230549 Seismic Restraint.

4. Arrange installation of units to provide access space around air-handling units for service and maintenance.
5. 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.
6. 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.

3.03 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to air-handling unit to allow service and maintenance.

D. Mount interior unit on vibration isolation springs.

E. Mount rooftop unit on:

1. Seismically restrained spring vibration isolation curb. Install with top surface of roof mounting frame level.
2. Or, factory built roof mounting frame where vibration will not be perceptible to occupants. Install with top surface of roof mounting frame level.

F. Install 3" flexible duct connection at inlets and outlets of units.

G. Connect piping with flexible connectors.

H. Connect condensate drain pans using ASTM B88, Type M or Type L copper tubing as shown on plumbing drawings and specifications. Extend to nearest roof receptor, floor sink, or floor drain. Construct deep P-trap at connection to drain pan and install cleanouts at changes in direction.

1. Install manufacturer provided condensate "air-trap" where provided with each air handling unit. Install trap per manufacturer's instructions and install condensate piping as required by local code.

I. Refrigerant Piping: Comply with applicable requirements in Section 232300 Refrigerant Piping Systems. Install shutoff valve and union or flange at each supply and return connection.

J. Coordinate duct installations and specialty arrangements with schematics on Drawings and with requirements specified in Section 233113 Air Distribution.

K. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233113 Air Distribution.

L. Control installers shall install all wiring associated with control signals into the air handlers.

M. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

N. Airflow measuring arrays installed in fan inlet volutes must be designed to withstand velocities encountered in this location. Mounting system is to be warranted against failure and consequent fan damage.

3.04 START-UP SERVICES

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

B. Tests and Inspections:

1. Leak Test: After installation, fill coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Automatic-Roll-Filter Operational Test: Operate filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating.
5. 2Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.05 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. 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.
4. 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 bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
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. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. 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 sheaves, fan pulleys 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.

C. ADJUSTING

1. Adjust damper linkages for proper damper operation.
2. Comply with requirements in Section 230593 Testing, Adjusting and Balancing.

D. CLEANING

1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

E. DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

3.06 AIR HANDLING UNIT CONFORMANCE

A. Manufacturer representative shall complete the following table and provide a copy with each submittal package to assure conformance to specifications:

B. Air Handler COMPLIANCE Checklist:

AIR HANDLER PERFORMANCE	
Manufacturer	
Dimensions (LxWxH inches)	
Operating Weight (LBS)	
Total Air Flow (CFM)	
System Supply Air Static Pressures (in. wg.)	
External Supply Ductwork	
Discharge Loss	
Cooling Coil	
Clean Filters	
Dirty Filter Allowance	
Damper/Louver/Fitting Loss	
Total Supply Fan Static	
Systems Return Air Static Pressures (in. wg.)	
External Return Air Static Pressure	
Entrance Loss	

Internal Louver/Damper/Fitting Loss	
Total Return Fan Static	
SUPPLY FAN PERFORMANCE	
Supply Fan BHP	
Supply Fan HP	
Supply Fan RPM	
Supply Fan Efficiency	
Direct Drive Plenum Fans	Yes or No
Fan Arrangement	
Pressure Class	
Aluminum Construction	Yes or No
Bearings (L 10/200000 hours)	Yes or No
Fans selected at rated motor RPM	Yes
RETURN FAN PERFORMANCE	
Return Fan BHP	
Return Fan HP	
Return Fan RPM	
Return Fan Efficiency	
Direct Drive Plenum Fans	Yes or No
Fan Arrangement	
Pressure Class	
Aluminum Construction	Yes or No
Bearings (L 10/200000 hours)	Yes or No
Fans selected at rated motor RPM	Yes
COIL PERFORMANCE	
Total Capacity (MBH)	
Sensible Capacity (MBH)	
Face Velocity (FPM)	
GPM	
Water Pressure Drop (ft. H2O)	
Coils/Fins per Inch/Rows	
Tube Size (inches)	
Tube thickness (inches)	
Tube return bend thickness (inches)	
Coils have 16 ga 304 SS	Yes or No
Drain pans are 304 SS	Yes or No
Coil blank offs are 304 SS	Yes or No
CABINET CONSTRUCTION	
Structural Steel Channel base	Yes or No
Tubular steel base	Yes or No
Can vary base height	Yes or No
Structural steel channel cross support	Yes or No
Formed channel cross support	Yes or No
Cross support max spacing	
Thermal break at joints	Yes or No
Outer steel (gauge)	
Solid inner steel (gauge)	

Insulation (wall/floor thickness) (inches)	
Standing seam construction	Yes or No
Welded frame construction	Yes or No
Bolted construction	Yes or No
Sheet metal screw construction	Yes or No
Standing seam roof with seam cleats	Yes or No
Roof attachment external to unit casing	Yes or No
Outdoor-pitched roof	Yes or No
Access door locations as required	Yes or No
Double seals on doors	Yes or No
Latches per door (number)	
Adjustable door hinges	Yes or No
Adjustable door latches	Yes or No
Access doors open against static pressure	Yes or No
Door safety "Kill" switches	Yes or No
Polyurethane paint	Yes or No
Vents and drains extended to outside cabinet	Yes or No
Cabinet Sounds data for inlet & outlet	
Supply connection at 125 & 1000 hz (db)	
Return connection at 125 & 1000 hz (db)	
Economizer has min/max dampers	Yes or No
Dampers sizing (maximum fpm)	
Outside air louver sizing (maximum fpm)	
Exhaust air louver sizing (maximum fpm)	
Exterior hoods	Yes or No
ADDITIONAL UNIT FEATURES	
Marine lights with GFI	Yes or No
Fan screen enclosures	Yes or No
Min OSA air flow station	Yes or No
Airflow stations on each fan	Yes or No
Motor removal rails	Yes or No
Bellmouth outlet	Yes or No
Roof curb	Yes or No
TEFC premium efficiency motors	Yes or No
Shaft grounding factory mounted on motors	Yes or No
Variable Frequency Drive (VFD) manufacturer	
VFD's are factory mounted & wired (UL508)	Yes or No
Data sheets for VFD's	Yes or No
Filters are size and type specified	Yes or No
Filter frames are face load type 8	Yes or No
Two filter gages (one per filter bank)	Yes or No
Weather covers for filter gages	Yes or No
Data sheets for filters	Yes or No
Data sheets for air flow stations	Yes or No

PROVIDE DETAILS	
Base/floor construction	Yes or No
Casing/cabinet construction	Yes or No
Access doors	Yes or No
Door hinges and latches	Yes or No
Fan curves	Yes or No
Pressure losses (including internal/external loss)	Yes or No
Sound data for inlet/outlet	Yes or No
Electrical wiring diagram	Yes or No
Vibration isolation detail	Yes or No
Coil construction	Yes or No
VFD mounting details	Yes or No
MANUFACTURER CAPABILITIES	
Fan Wheel Manufacturer	
Coil Manufacturer	
Dampers Manufacturer	
Louver Manufacturer	
Isolator Manufacturer	
Have a certified UL508 electrical shop	Yes or No
ARI certified for coils	Yes or No
Coil Testing Capabilities	Yes or No
AMCA certified for blowers	Yes or No
UL-508	Yes or No
AMCA 210 accredited lab	Yes or No
AMCA 300 accredited lab	Yes or No
Ability to perform leak tests	Yes or No
UL-508 compliance	Yes or No
Unit ETL or UL listing	Yes or No

END OF SECTION 237312

SECTION 237413 - PACKAGED HVAC UNITS (UP TO 25 TONS)

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Packaged unit
2. Controls and control connections
3. Electrical power connections
4. Roof mounting frame and base

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230700: Mechanical Insulation

D. Section 233113: Air Distribution

E. Division 26: Electrical

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide packaged units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
   a. 99 - Standards Handbook
   b. 210 - Laboratory Methods of Testing Fans
   c. 300 - Reverberant Room Method for Sound Testing of Fans
   d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   e. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 210/240 – Performance Rating of Unitary Air Conditioning & Air-Source Heat Pump Equipment
   b. 270 - Sound Rating of Outdoor Unitary Equipment
   c. 340/360 – Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 15 - Safety Code for Mechanical Refrigeration
   b. 193 – Method of Test for Determining the Air Leakage of HVAC Equipment. All systems that move less than 3,000 cfm shall comply with less than 1.4% cabinet leakage rate.

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of units, which have been listed and labeled by UL.
9. Minimum Efficiency: Minimum efficiencies shall meet or exceed the values listed in this specification.

1.05 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

   1. The proposed substitution does not affect dimensions shown on drawings.
   2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
   3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
   4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.06 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for packaged units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals; in accordance with requirements of Division 1.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 PACKAGED ROOFTOP HEATING/COOLING UNIT (UP TO 20 TONS)

A. General:

1. Outdoor rooftop mounted, electrically controlled heating and cooling unit. Unit shall discharge supply air downward or horizontally as shown on contract drawings.
2. Unit shall be rated in accordance with ARI Standards 210, 240 and 270. Designed in accordance with UL Standard 465.
3. Unit shall be designed to conform to ANSI/ASHRAE 15.
4. Unit shall be UL tested and certified in accordance with ANSI Z21.47 Standards and CSA or CGA certified as a total package.
5. Roof curb shall be designed to conform to NRCA Standards.

6. Insulation and adhesive shall meet NFPA 90A requirements for flame spread and smoke generation.

B. Manufacturers: Carrier, Trane, Daikin, York, Lennox, Aaon, Engineered-Air, or equal.

C. Equipment:

1. General:
   a. Factory assembled, single piece heating and cooling unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, refrigerant charge (R-410A) and special features required prior to field start-up.

2. Unit Cabinet:
   a. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a pre-painted baked enamel finish on all externally exposed surfaces.
   b. Insulation: See Table below.
   c. Cabinet panels shall be easily removable for servicing. See Table below.
   d. Filters will be accessible through a hinged access door, and will require no panel or screw removal.
   e. Holes shall be provided in the base rails for rigging shackles to facilitate maneuvering and overhead rigging.
   f. Unit shall have a factory installed internal condensate drain trap made of a non-corrosive material, providing a minimum 3/4" connection.

3. Fans:
   a. Indoor blower (evaporator fan):
      1) Fan shall be direct or belt driven as specified here (See matrix below). If belt driven the drive shall include an adjustable pitch motor pulley.
      2) Bearings shall be sealed, permanently lubricated ball bearing type for longer life and lower maintenance.
   b. Indoor blower shall be made from steel with a corrosion resistant finish and shall be dynamically balanced.
   c. Outdoor (condenser) fan shall be of the direct driven propeller type and shall discharge air vertically upward.

4. Compressor:
   a. Fully hermetic type, internally protected.
   b. Factory rubber shock mounted and internally spring mounted for vibration isolation.
   c. Equipped with a factory installed crankcase heater to minimize liquid refrigerant accumulation in compressor during shutdown and prevent refrigerant dilution of oil.

5. Coils:
   a. Evaporator and condenser coils shall have fins mechanically bonded to seamless tubes with all joints brazed.
   b. Tube sheet openings shall be belled to prevent tube wear.
   c. Evaporator coil shall be of the full-face active design, degreased at the factory.

6. Heating Section:
   a. Gas Heating Section:
      1) Induced draft combustion type with intermittent direct spark ignition system and redundant main gas valve.
      2) Heat exchanger: See matrix below.
      3) All gas piping shall enter the unit cabinet at a single location.

7. Refrigerant Components: Refrigerant circuit components shall include:
   a. Refrigerant feed system.
   b. Filter drier.
   c. Service gauge connections on suction, discharge and liquid lines.

8. Filter Section:
   a. Standard filter section shall consist of factory installed low velocity, disposable filters of commercially available sizes.
   b. Filter face velocity shall not exceed 500 fpm at nominal airflows.

9. Controls and Safeties:
   a. Unit Controls: Unit shall be complete with self-contained low voltage control circuit protected by a manually resettable circuit breaker.
   b. Fault Detection and Diagnostics: Provide an on-board fault detection and diagnostics system capable of identifying specific faults including alarm for low refrigerant charge, failed economizer function.
   c. Safeties:
      1) Unit shall incorporate a solid state compressor protector which provides reset capability at the space thermostat, should any of the following standard safety devices trip and shut off compressor:
         a) Compressor over temperature, overcurrent.
         b) Loss of charge/low pressure switch.
         c) Freezestat, evaporator coil.
         d) High-pressure switch.
      2) Gas Heating section shall be provided with the following minimum protections:
         a) High temperature limit switch.
         b) Induced draft motor centrifugal switch.
         c) Flame rollout switch (manual reset).
         d) Flame proving controls.

10. Operating Characteristics:
    a. Unit shall be capable of starting and running at 115°F ambient outdoor temperature per maximum load criteria of ARI Standard 210/240.
    b. Compressor with standard controls shall be capable of operation down to 25°F ambient outdoor temperature.
    c. Unit provided with fan time delay of 55 seconds to prevent cold air delivery before heat exchanger warms up.

11. Electrical Requirements: All unit power wiring shall enter unit cabinet at a single factory predrilled location.
12. Motors:
    a. Compressor motors shall be cooled by suction gas passing through motor windings and shall have line break thermal and current overload protection.
    b. Indoor blower motor shall have permanently lubricated bearings and inherent automatic reset thermal overload protection.

c. Outdoor totally enclosed motor shall have permanently lubricated bearings, and inherent automatic reset thermal overload protection.
d. Induced draft motor shall have permanently lubricated sealed bearings and inherent automatic reset thermal overload protection.

13. Medium Size Package Rooftop Unit (7-1/2 -25 ton) Equipment Conformance List: The scheduled units within this size category shall be configured with the following selected feature options.

Medium Size Package Rooftop Unit (7-1/2 -25 ton) Equipment Requirements			
Component	**Feature**	**Specification Options**	**Specified Alternative**
Unit Cabinet	Wall Construction	Single wall	X
		Double wall	
	Liner Options	Foil faced insulation	X
	Insulation	1/2" Insulation	
		1" insulation	X
	Maintenance Access	Tool required	
		Tool free	X
		Hinged panels	X
		Non-hinged panels	
	Condensate Pan	Plastic	
		Galvanized	X
		Stainless	
Supply Fan	Fan Access	Slide out cassette	X
		Non-slide out	
	Fan Wheel Construction	Fully welded fan wheels	X
	Motor type	ECM motor	
		Conventional	X
	Drive	Belt and sheaves	
		Direct	X
OSA Intake	Fixed OSA		
	Economizer	Modulating dampers	X
Relief Air	Relief provisions	Barometric damper only	
		Prop relief fan with damper	X
		Return fan	
Compressor	Type of compressor	Scroll	X
		Digital Scroll	
		Variable Speed	
Cooling Efficiency		EER	See schedule
		IEER or SEER	See schedule
Evaporator	Coil Construction	Copper tubes/Aluminum fins	X
		Epoxy coated coil	
Condenser	Coil Construction	Copper tubes/Aluminum fins	X
		All aluminum coil	
		Copper tubes/Copper fins	
		Epoxy coated coil	
	Condenser fan	ECM type motor	X
		Constant speed motor	
Reheat	Reheat Coil	Modulating hot gas reheat coil	X

		Not required	
Filters	Filter type	2" MERV 8 pleated filter	X
		4" MERV 13 pleated filter	
Electric Heat	Control	Step controller	
		SCR controller option	X

Medium Size Package Rooftop Unit (7-1/2 -25 ton) Equipment Requirements (Continued)			
Component	**Feature**	**Specification Options**	**Specified Alternative**
Gas Heat	Type of Heat Exchanger (HEX)	Aluminized steel HEX	
		Stainless HEX	X
		Condensing Stainless HEX	
	Control	Stepped control	
		Modulating control	X
	Furnace Efficiency		See schedule
Hybrid Heat Pump/Gas Heat Option			
HW Coil		Coil with modulating valve	
Heat Recovery		Heat wheel with filters, bypass dampers, and controls	
Controls	Economizer	Fully integrated economizer controls	X
	Single Zone VAV		
	Full VAV Control		X
	CO2 Sensor		X
	OSA Monitor and controller		X
	Heat recovery control		
	Dehumidification Control		
	Factory digital controls	Zone controls by others	X
		Equip with zone controls and unit programming panel	
	BAS interface options	BACnet interface	X
		LonTalk Interface	
	Smoke Detector	Provide with unit	X
Electrical	Single point connection		X
	Powered convenience outlet	Receptacle	X

14. Other Features and Required Equipment: Provide the following with units.
    a. Roof Curb:
        1) Formed galvanized steel with wood nailer strip and capable of supporting entire unit weight.
        2) Seismically restrained spring isolating curb (See Section 230548 Vibration Seismic).
    b. Head Pressure Control Package: Consists of solid-state control and condenser coil temperature sensor to maintain condensing temperature between 90°F and 110°F

at outdoor ambient temperatures down to -20°F by either condenser fan speed modulation or condenser fan cycling.

c. Remote Control Panel: Panel shall be a decorative, indoor, wall mounted panel consisting of:
   1) Two stage heat/two stage cool thermostat.
   2) Automatic changeover.
   3) System switch with HEAT - COOL - AUTO - OFF settings.
   4) Fan switch with ON - AUTO settings.
   5) Indicator lights for HEAT - COOL - FAN operation.
   6) Three unused indicator lights for field use.

2.02 PROGRAMMABLE THERMOSTAT

A. Thermostat with 365-day programmability that allows the building occupants to program the temperature setpoints for at least four periods within 24 hours. A minimum of 5 holidays shall be programmable for up to 5 years. Daylight savings shall be provided as a standard feature in the programming calendar.

1. Manufacturers: Honeywell VisionPRO 8000 Series, Honeywell Prestige THX 9000 Series, Honeywell TB7600 Series, Venstar ColorTouch T6000 Series, EnTouch Pro/One or equal.

B. Minimum thermostat features shall include, but not limited to, the following:

1. The thermostat shall have a touch screen and shall display both room temperature and cooling and heating setpoints simultaneously, and shall indicate when cooling or heating and what stage is energized on the main screen.
2. Programming may be accomplished at the thermostat, or via free software. The program shall have an override mode to provide comfort on demand while in an unoccupied period. The unoccupied override shall be adjustable by pushing an override button and selecting thirty minute increments, up to four hours.
3. The setback override shall be activated by a single button, and deactivated on demand.
4. Setpoints shall be adjustable from 35^0F to 99^0F, with a minimum 5°F adjustable deadband available.
5. Dual setpoints shall be provided with the ability to individually set heating and cooling temperatures with adjustable heating and cooling setpoint limits. Initial occupied mode cooling setpoint of 75^0F and heating setpoint of 70^0F. Initial unoccupied mode cooling setpoint of 85^0F and heating setpoint of 55^0F

C. The thermostat shall be capable of independently controlling an individual system, with up to three stages of heating and two stages of cooling, fan, and reversing valve.

1. The fan shall be programmable to operate continuously during occupied periods and in auto mode during unoccupied periods.

D. Controls shall be capable of alternating compressor starting sequence with a built in lead-lag operating logic.

1. Equipment protection options shall be provided to prevent compressor short-cycling, and to limit the number of cycles per hour. These options shall be overridden for use with zoning systems.

E. Pre-Occupancy purge cycle that energizes the fan before the programmed occupancy time, adjustable up to three (3) hours in 15-minute increments.

1. Configurable terminals shall be provided for remote indoor, remote outdoor or remote supply air temperature sensing.

F. Multiple security levels to limit access to programming and configuration and will allow for a custom passcode. The various security levels will allow controlled access to programming, unoccupied override, and thermostat mode.

G. All programming information, except time of day, shall reside in nonvolatile memory. During a power failure, the thermostat shall maintain its program indefinitely without the use of batteries.

H. Wi-Fi capable and controlled through local wireless internet routers. The thermostat shall be capable of receiving an automated demand response signal from the local electrical utility, and automatically reset the cooling and heating setpoints during the demand event. When the demand event is terminated by the local electrical power utility, the thermostat will reset to normal occupied and unoccupied setpoints.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that mounting surface, e.g. roof, is ready to receive work.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide layout drawings of units, locations and power requirements to electrical installer.

C. Install minimum 30% efficiency air filters in unit during installation phase. Do not operate the unit without filters in place.

D. Mount rooftop unit on:

1. Seismically restrained spring vibration isolation curb. Install with top surface of roof mounting frame level.
2. Or, factory built roof mounting frame where vibration will not be perceptible to occupants. Install with top surface of roof mounting frame level.

E. Install 3" flexible duct connection at inlets and outlets of units.

F. Install condensate drain piping and traps in accordance with manufacturer's instructions, per local code and as shown on the drawings.

1. Install manufacturer provided condensate "air-trap" where provided with each unit. Install trap per manufacturer's instructions and install condensate piping as required by local code.

G. Control installers shall install thermostat and all wiring associated with control signals into the units.

H. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

I. Install a new set of filters prior to final air balance and substantial completion.

3.03 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the job site.

END OF SECTION 237413

SECTION 237434 – LARGE PACKAGED HVAC UNITS (20 - 150 TONS)

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Packaged unit
2. Controls and control connections
3. Electrical power connections
4. Roof mounting frame and base

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230548: Vibration Isolation for Piping, Ductwork, and Equipment

C. Section 230593: Testing, Adjusting and Balancing

D. Section 230900: Building Automation System (BAS) Controls

E. Section 233113: Air Distribution

F. Division 26: Electrical

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide packaged units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
   a. 99 - Standards Handbook
   b. 210 - Laboratory Methods of Testing Fans for Rating
   c. 300 - Reverberant Room Method for Sound Testing of Fans
   d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data

e. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 210/240 – Performance Rating of Unitary Air Conditioning & Air-Source Heat Pump Equipment
   b. 270 - Sound Rating of Outdoor Unitary Equipment
   c. 340/360 – Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 15 - Safety Code for Mechanical Refrigeration
   b. 193 – Method of Test for Determining the Air Leakage of HVAC Equipment. All systems that move less than 3,000 cfm shall comply with less than 1.4% cabinet leakage rate.

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of units, which have been listed and labeled by UL.
9. Minimum Efficiency: Minimum efficiencies shall meet or exceed the values listed in this specification.

1.05 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:

1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.06 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for packaged units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals; in accordance with requirements of Division 1.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

1.09 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Provide five (5) year warranty on compressors.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The following manufacturers will be considered provided they comply with contract documents. No substitutions will be permitted.

1. Daikin
2. Trane

3. Carrier
4. York
5. Aaon
6. Mammoth
7. Engineered Air
8. Seasons 4
9. Energy Labs
10. Governaire

2.02 GENERAL DESCRIPTION

A. Unit performance and electrical characteristics shall be per the schedule on the drawings.

B. Configuration: Fabricate as detailed on the drawings:

1. Supply fan section
2. Return fan section
3. Economizer section
4. Filter section
5. Heating section
6. Cooling coil section
7. Discharge plenum
8. Condensing unit section

C. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Units shall be of a modular design with factory installed access sections available to provide maximum design flexibility. Each unit shall be completely factory assembled and shipped in one piece, unless split due to transport restrictions. One piece packaged units shall be shipped fully charged with Refrigerant R-410A. Split systems and all units split between the evaporator and the condensing section are to be shipped with a nitrogen holding charge only.

D. Factory Testing: The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of the supply fan assembly, return/exhaust fan assembly as applicable, a refrigeration circuit run test, a unit control system operations checkout, test and adjustment of the gas furnace as applicable, a unit refrigerant leak test and a final unit inspection.

E. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

F. Performance: All scheduled capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

2.03 CABINET, CASING AND FRAME

A. Standard double-wall construction for all side wall access doors and floor areas shall be provided with 22-gauge (minimum) solid galvanized steel inner liners to protect insulation

during service and maintenance. A combination of solid and perforated galvanized steel liners shall be provided throughout. Perforated liners to be used in the supply and return air plenums to provide improved sound attenuation. All cabinet insulation, except floor panels, shall be a nominal 2" thick, 1-1/2 lb. density, R6.5, glass fiber. All floor panels shall include double wall construction and include a nominal 2" thick, 1-1/2 lb. density, R6.5 glass fiber insulation.

B. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished surface to withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance. Service doors shall be provided on both sides of each section in order to provide user access to all unit components. Service doors shall be constructed of heavy gauge galvanized steel with a gauge galvanized steel interior liner. All service doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system that is operated by a single, flush mounted handle. The latch system shall feature a staggered engagement for ease of operation. Removable panels, or doors secured by multiple, mechanical fasteners are not acceptable.

C. The unit base frame shall be constructed of 15-gauge for models through 40 ton and 13-gauge for larger units using pre-painted galvanized steel. The unit base shall overhang the roof curb for positive water runoff and shall have a formed recess that seats on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

2.04 SUPPLY AND RETURN FANS

A. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide an L-50 life (minimum) at 200,000 hours. The entire fan assembly shall be isolated from the fan bulkhead and mounted on rubber-in-shear isolators, spring isolators, or spring isolators with seismic restraints as scheduled. Fixed or adjustable pitch V-belt drives with matching belts shall be provided ass scheduled. V-belt drives shall be selected at the manufacturer's standard service factor.

B. Fan motors shall be heavy-duty 1800 rpm open drip-proof (ODP) or totally enclosed TEFC type with grease lubricated ball bearings. Motors shall be premium efficiency. Motors shall be mounted on an adjustable base that provides for proper alignment and belt tension adjustment.

C. Airfoil supply fans

1. The supply fan shall be single width, single inlet (SWSI) airfoil centrifugal fan or double width, double inlet (DWDI) airfoil centrifugal fan as scheduled. The fan wheel shall be Class II construction with aluminum fan blades continuously welded to the back plate and end rim. Fans shall be mounted using shafts and hubs with mating keyways.

D. Forward curved supply fans

1. RPS and RFS supply fan shall be double width, double inlet forward curved centrifugal fan. All fans shall be mounted using shafts and hubs with mating keyways. The forward curved fan wheel and housing shall be fabricated form galvanized steel and shall be Class II construction to satisfy the specified application.

E. Airfoil return fans

1. A single width, single inlet (SWSI) airfoil centrifugal return air fan shall be provided. The fan shall be Class II construction. The fan wheel shall be Class II construction and fabricated from heavy-guage aluminum with fan blades continuously welded to the back plate and end rim. The fan shall be mounted using shafts and hubs with mating keyways.

F. Forward curved return fans

1. Double width, double inlet (DWDI) forward curved centrifugal return air fans shall be provided. Fans shall be mounted using shafts and hubs with mating keyways. The fan wheels and housings shall be fabricated from painted steel and shall be Class I construction to satisfy the specified application.

G. The supply air fan and return air fan sections shall be provided with an expanded metal belt guard where fans may be accessed without door interlock kill switches.

2.05 PROPELLER EXHAUST FANS (NO ENERGY RECOVERY WHEEL)

A. Belt drive propeller exhaust fans shall be provided for relief air duty. Propellers shall be constructed with fabricated steel, and shall be securely attached to fan shafts. All propellers shall be statically and dynamically balanced. Motors shall be permanently lubricated, heavy-duty type, carefully matched to the fan load. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Bearings shall be selected for a minimum L-10 life in excess of 100,000 hours at maximum cataloged operating speeds. Drives shall be sized for a minimum of 105 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to wheel and motor shafts. Motor sheaves shall be adjustable for system balancing. Drive frame and panel assemblies shall be galvanized steel. Drive frames shall be formed channels and panels shall be welded construction. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for both sound and air performance.

B. The exhaust fans shall be controlled by a variable frequency drive.

C. The exhaust air fan sections shall be provided with an expanded metal belt guard.

2.06 VARIABLE AIR VOLUME CONTROL

A. An electronic variable frequency drive shall be provided for the supply, return and exhaust fans as scheduled. Each drive shall be factory installed downstream of the filters in a manner that the drive(s) are directly cooled by the filtered, mixed air stream. Drives shall meet UL Standard 95-5V and the variable frequency drive manufacturer shall have specifically approved them for plenum duty application. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are to be accessible through a hinged door assembly complete with a single handle latch mechanism. Mounting arrangements that expose drives to high temperature, unfiltered ambient air is not acceptable.

B. The unit manufacturer shall install all power and control wiring.

C. The supply air fan drive output shall be controlled by the factory installed main unit control system and drive status and operating speed shall be monitored and displayed at the main unit control panel. The supply and return/exhaust fan drive outputs shall be independently controlled in order to provide the control needed to maintain building pressure control. Supply and return/exhaust air fan drives that are slaved off of a common control output are not acceptable.

D. All drives shall be factory run tested prior to unit shipment.

2.07 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be numbered and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, high temperature sensor, and a 115-volt receptacle shall also be provided with unit.

B. Provide a receptacle powered by a factory installed and wired 120V, 15-amp power supply. The power supply shall be wired to the line side of the unit's main disconnect, so the receptacle is powered when the main unit disconnect is off. This option shall include a weatherproof transformer and disconnect. The electrical circuit shall complete with primary fused, overload protection.

C. Each compressor and condenser fan motor shall be furnished with contactors, current sensing manual motor and short circuit protection, and inherent thermal overload protection. Supply and return fan motors shall have Circuit breakers and built in overload protection with VFDs. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance. All 115 to 600 voltage wire shall be protected from damage by raceways or conduit.

D. A factory installed and wired marine service light, with switch and receptacle, shall be provided in the supply air and return/exhaust fan section on units wider than 7' where this is a standard factory option. The separate, main unit service receptacle electrical circuit shall also power the light circuit.

E. Phase failure and under voltage protection on three-phase motors shall be provided to prevent damage from single phasing, phase reversal, and low voltage conditions.

F. Ground fault protection shall be provided to protect against arcing ground faults.

G. Further required options:

1. Smoke Detector: Factory mounted smoke detectors shall be factory installed in the supply and/or return air openings as required by the applicable mechanical code and building code. Smoke detectors to be ionization type, which responds to invisible products of combustion without requiring the sensing of heat, flame or visible smoke. Upon sensing smoke, the unit shall provide a control output for use by the BAS.
2. UV Lights: Unit to have factory-mounted UV lights located on the leaving air side of the cooling coil. Unit to have view port to allow for visual indication of operation thorugh UV

resistant glass. Unit to have door interlocks on each door accessing UV light. Interlock to kill power to UV light when door is opened.

a. Lamp and fixture to consist of a housing, power source, lamp sockets, and lamp. All componentes are to be constructed to withstand typical HVAC environments and are UL/C-UL listed. Housings are to be constructed of type 304 stainless steel and are to be equipped with both male and female power plugs with one type at each end to facilitate simple fixture-to-fixture plug-in for AC power.
b. Power source shall be an electric, rapid-type with overload protections and is to be designed to maximize radiance and reliability at UL/C-UL listed temperatures of 55°F–135°F. Power source will include RF and EMI suppression.
c. Sockets shall be medium bi-pin, single click safety, twist lock type and are to constructed of a UVC-resistant polycarbonate.
d. Lamp shall be a high output, hot cathode, T8 diameter, medium bi-pin that produces UVGI of 254 nm. Each tube produces the specified output at 500 fpm and air temperatures of 55°F–135°F.

3. A non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. A second switch may be provided for the condensing section as required. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle. Externally mounted handle is designed to prohibit opening of the control panel door without the use of a service tool.

2.08 HEATING AND COOLING SECTIONS

A. Cooling

1. The coil section shall be complete with factory piped cooling coil and sloped drain pan. Hinged access doors on both sides of the section shall provide convenient access to the cooling coil and drain pan for inspection and cleaning.
2. Submittals must demonstrate that scheduled unit leaving air temperature (LAT) is met, that fan and motor heat temperature rise (TR) have been considered, and scheduled entering air temperature (EAT) equals mixed air temperatuare (MAT)
3. Draw-through cooling—Scheduled EAT equals cooling coil EAT and scheduled unit LAT equals cooling coil LAT plus TR.
4. Blow-through cooling—Cooling coil EAT equals scheduled EAT plus TR and scheduled unit LAT equals cooling coil LAT.
5. Direct expansion (DX) cooling coils shall be fabricated of seamless 1/2" or 5/8” diameter high efficiency copper tubing that is mechanically expanded into high efficiency aluminum or copper plate fins. Coils shall be a multi-row, staggered tube design. All units shall have two independent refrigerant circuits and shall use an interlaced coil circuiting that keeps the full coil face active at all load conditions.
6. All coils shall be factory leak tested with high pressure air under water.
7. A stainless steel, positively sloped drain pan shall be provided with the cooling coil. The drain pan shall extend beyond the leaving side of the coil and underneath the cooling coil connections. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall be connected to a threaded drain connection extending through the unit base. Units with stacked cooling coils shall be provided with a secondary drain pan piped to the primary drain pan.

B. Gas Heating Option

1. A natural gas fired furnace shall be installed in the unit heat section. The heat exchanger shall include a type 321 stainless steel cylindrical primary combustion chamber, a type 321 stainless steel header, type 321 stainless steel secondary tubes and type 321stainless steel turbulators. Carbon and aluminized steel heat exchanger surfaces are not acceptable. The heat exchanger shall have a condensate drain. Clean out of the primary heat exchanger and secondary tubes shall be accomplished without removing casing panels or passing soot through the supply air passages. The furnace section shall be positioned downstream of the supply air fan.
2. Modulating Control:
    a. The furnace will be supplied with a modulating forced draft burner. The burner shall be controlled for low fire start. The burner shall be capable of continuous modulation between 33% and100% of rated capacity and shall operate efficiently at all firing rates.
    b. Or, the furnace shall be supplied with a forced draft burner capable of continuous modulation between 5% and 100% of rated capacity, without steps. The burner shall operate efficiently at all firing rates. The burner shall have proven open damper low-high-low pre-purge cycle, and proven low fire start. The combustion air control damper shall be in the closed position during the off cycle to reduce losses.

3. The burner shall be specifically designed to burn natural gas and shall include a microprocessor based flame safeguard control, combustion air proving switch, pre-purge timer and spark ignition. The gas train shall include redundant gas valves, pressure regulator, shutoff cock, pilot gas valve, pilot pressure regulator, and pilot cock. The burner shall be rated for operation and full modulation capability at listed inlet gas pressures.
4. The gas burner shall be controlled by the factory installed main unit control system.
5. The burner shall be fired, tested and adjusted at the factory. Final adjustments shall be made in the field at initial start-up by a qualified service technician to verify that installation and operation of the burner is according to specifications.

C. Electric Heating Option

1. Staged electric heating coils shall be factory installed in the unit heat section. Heating coils shall be constructed of a low watt density, high nickel-chromium alloy resistance wire, mechanically stacked and heli-arc welded to corrosion resistant terminals. A corrosion resistant heavy gauge rack shall support the elements. Safety controls shall include automatic reset high limit control for each heater element with manual reset backup line break protection in each heater element branch circuit. Heating element branch circuits shall be individually fused to maximum of 48 amps per NEC requirements. The electric heat section shall be positioned downstream of the supply air fan.
2. The electric heat elements shall be controlled by the factory installed main unit control system.

2.09 FILTERS

A. Draw-through Filters

1. Unit shall be provided with a filter section to support 2” pre-filters and high-efficiency cartridge final filters. The filter section shall be supplied complete with the filter rack as an integral part of the unit.

2. 2" thick 30% (MERV-8) efficient pleated panel filters shall be provided. Filters shall be frame mounted and shall slide into galvanized steel racks contained within the unit. Filters shall be accessible from both sides of the filter section.
3. 12" deep cartridge, 90-95% efficient (MERV-14) shall be provided. Cartridge filters shall consist of filter media permanently attached to a metal frame and shall slide into a gasketed, extruded aluminum rack contained within the unit. The filter rack shall have secondary gasketed, hinged end panels to insure proper sealing. Filters shall be accessible from both sides of the filter section.

B. Final Filters Option

1. Final Filters—Unit shall be provided with a final filter section downstream of the supply fan. Unit to have 40" of unit length between the fan discharge and the final filters to allow for proper air distribution. The final filter section shall be supplied complete with the filter rack as an integral part of the unit. The final filter section shall be provided with cartridge filters.
2. 4" to 12" deep, final filters, as scheduled. For units with gas or electric heat, high temperature cartridge filters rated for 500°F shall be used. Cartridge filters shall consist of filter media permanently attached to a metal frame and shall slide into a gasketed, extruded aluminum rack contained within the unit. The filter rack shall have secondary gasketed, hinged end panels to insure proper sealing. Filters shall be accessible from both sides of the filter section.
3. Filters shall be provided with antimicrobial treatment.

2.10 OUTDOOR / RETURN AIR SECTION

A. Return Air Plenum

1. Unit shall be provided with a return air plenum for handling 100% re-circulated air. The 100% return air plenum shall allow return air to enter from the bottom or back of unit as scheduled.
2. 0%–100% Outdoor Air Economizer (no energy recovery)
    a. Unit shall be provided with an outdoor air economizer section. The 0 to 100% outside air economizer section shall include outdoor, return, and exhaust air dampers. Outdoor air shall enter from both sides of the economizer section through horizontal, louvered intake panels complete with rain lip and bird screen. The floor of the outdoor air intakes shall provide for water drainage.
    b. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be opposed sets of parallel blades, arranged vertically to converge the return air and outdoor air streams in multiple, circular mixing patterns. Damper blades shall be fully gasketed and side sealed. Damper leakage shall be less than 0.2% at 1.5- inches static pressure differential. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.
    c. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit if scheduled. An electric actuator shall provide positive closure of the exhaust damper. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with urethane gasketing on contact edges.
    d. Control of the dampers shall be by a factory installed actuator. Damper actuator shall be of the modulating, spring return type. If outdoor air is suitable for "free"

cooling, the outdoor air dampers shall modulate in response to the unit's temperature control system.

B. Minimum Ventilation Air Control Option

1. A precision ventilation control system shall be provided as an integral part of the 0–100% outdoor air economizer system. It shall directly measure the total mass volume of air flowing through the outdoor air intakes. The unit's control panel shall automatically adjust the outdoor damper position to maintain minimum outdoor air cfm. The airflow station shall be capable of accurately measuring minimum outdoor air volume within 5 % to continuously satisfy the requirements of ASHRAE 62. Third party verification of measurement accuracy shall be verified by a nationally recognized independent testing agency.

C. Energy Recovery Option

1. Unit shall be provided with a modulating outdoor air economizer section with an ARI Certified energy recovery wheel. The economizer section shall include outdoor, return and return exhaust air control and bypass dampers and damper actuators shall be included that automatically bypass outdoor air around the wheel during economizer operation. Outdoor air shall enter at the back of the section through a factory installed hood capable of handling 100% outdoor air. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same pre-painted finish as the main unit. The hood shall include a bird screen to prevent infiltration of foreign materials and a rain lip to drain water away from the entering air stream. Return air shall enter through the bottom of the unit. The entire section shall be double wall construction.
2. The enthalpy wheel shall be constructed of corrugated synthetic fibrous media, with a desiccant intimately bound and uniformly and permanently dispersed throughout the matrix structure of the media. Rotors with desiccants coated, bonded, or synthesized onto the media are not acceptable due to delamination or erosion of the desiccant material. Media shall be synthetic to provide corrosion resistance and resistance against attack from laboratory chemicals present in pharmaceutical, hospital, etc. environments as well as attack from external outdoor air conditions. Coated aluminum is not acceptable. Face flatness of the wheel shall be maximized (+/- 0.032 in) in order to minimize wear on inner seal surfaces and to minimize cross leakage. Rotor shall be constructed of alternating layers of flat and corrugated media. Wheel layers should be uniform in construction forming uniform aperture sizes for airflow. Wheel construction shall be fluted or formed honeycomb geometry so as to eliminate internal wheel bypass. Wheel layers that can be separated or spread apart by airflow are unacceptable due to the possibility of channeling, internal bypass or leakage, and performance degradation. The media shall be in accordance with NFPA or UL guidelines. The desiccant material shall be a molecular sieve, and specifically a 4A or smaller molecular sieve to minimize cross contamination. The wheel frames shall consist of evenly spaced steel spokes, galvanized steel outer band and rigid center hub. The wheel construction should allow for post fabrication wheel alignment. The wheel seals shall be brush seals, neoprene bulb seals or equivalent. Seals should be easily adjustable. Cassettes shall be fabricated of heavy duty reinforced galvanized steel. Cassettes shall have a built in adjustable purge section minimizing cross contamination of supply air. Bearings shall be inboard, zero maintenance, permanently sealed roller bearings, or alternatively, external flanged bearings. Drive systems shall consist of fractional horsepower A.C. drive motors with multilink drive belts.

3. The wheel capacity, air pressure drop, and efficiency shall be tested in accordance with NFPA or UL guidelines and shall be UL recognized or equivalent. The wheel capacity, air pressure drop and effectiveness shall be ARI certified by ARI and its testing agencies. Alternative independent performance testing must be pre-approved to be accepted.
4. Wheel shall be provided with variable speed control for frost protection.
5. The wheel recovers energy from the factory-supplied return/exhaust section and includes an SWSI airfoil fan and motor in accordance with construction already specified. Gravity relief dampers and fold out exhaust hood shall be provided. All necessary exhaust fan motor starters, branch short circuit protection, and wiring and controls shall be provided. Two inch, 30% pleated filters shall be provided in both air inlets to protect the wheel from dust and dirt in both the outdoor and return/exhaust air paths. Damper blades shall be fully gasketed and side sealed and arranged horizontally in the hood. Damper leakage shall be less than 0.2% at 1.5-inches static pressure differential. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.

2.11 ACCESS SECTION OPTION

A. Unit shall be provided with factory installed access sections located upstream and/or downstream of the supply air fan, as required to provide access. Access sections shall have hinged access doors on both sides of the section and shall have the same construction features as the rest of the unit.

B. Blank Compartment

1. An insulated, blank compartment shall be provided as required. The section shall be located after the discharge plenum and will be out of the air stream. The section shall be complete with insulation, double wall construction and a service light.

2.12 STATIC AIR MIXER (AIR BLENDER) OPTION

A. A static air mixing device shall be factory installed between the outside/return air section and the filter section. The static air mixer shall be installed with proper upstream and downstream distances. The mixing device shall perform at face velocities from 500 fpm through 2500 fpm with no loss in mixing performance. The mixing device shall provide mixing and distribution of the outside and return air streams to minimize the threat of coil freeze-up during operation and to improve temperature control. Acceptable manufacturers are Blender Products or Kees.

2.13 SOUND ATTENUATOR OPTION

A. A section shall be provided by the air handling unit manufacturer as an integral part of the unit to attenuate fan noise at the source. Variable range of splitter thickness and air passages provided to optimize acoustic performance and energy conservation. The attenuators shall have perforated double-wall construction and be located downstream of the supply fan. Hinged access doors shall be provided on both sides of the section and shall have the same construction as the rest of the unit. Combustion rating for the silencer acoustic fill shall not be greater than the following UL fire hazard classification:

B. Flame Spread - 15

C. Fuel Contributed - 0

D. Smoke Developed - 0

E. Tested in accordance with UL Test Procedure 723.

F. The attenuator rating shall be determined using the duct-to-reverberant room test method which provides for airflow in both directions through the attenuator in accordance with latest version of ASTM specification E-477. Insertion Loss Ratings (ILR) shall be:

Octave Band at Center Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000
ILR (no Tedlar)	7	9	22	28	29	29	18	12
ILR (Tedlar coating)	6	10	20	16	14	18	13	12

G. Manufacturer shall provide certified test data on dynamic insertion loss, self-generated sound power levels, and aerodynamic performance for reverse and forward flow test conditions to the design professional in writing as least 10 days prior to the bid.

2.14 SUPPLY AND RETURN PLENUM ACCESSORIES

A. The plenums shall be insulated to enhance sound attenuation. The plenum sections shall have bottom, side or front, or back openings as shown on drawings.

B. Where specified on drawings, provide combination burglar bar/safety grates in bottom openings. Burglar bar/safety grates shall be made of 3/4" diameter ground and polished steel shaft welded to a galvanized steel frame.

C. Where specified on drawings, provide isolation dampers shall be provided in the bottom openings.

2.15 CONDENSING UNIT SECTION

A. The condensing section shall be open on the sides and bottom to provide access and to allow airflow through the coils. Condenser coils shall be cast aluminum, micro-channel coils, or copper tubes mechanically bonded to aluminum plate fins. Coils are recessed so the cabinet provides built in hail protection. Liquid tight conduit shall be provided for all exposed condenser and compressor wiring. Provide coil with a corrosion resistant coating that shall withstand ASTM B117 Salt Spray test for 6,000 hours and ASTM G85 A2 Cyclic Acidified Salt Fog test for 2,400 hours.

B. Condenser fans shall be direct drive, propeller type designed for low tip speed and vertical air discharge.

C. Acoustical Treatment: For units mounted on grade within 50’ of property lines and/or building windows provide special quiet condenser fans consisting of seven aerodynamic, airfoil blades with serrated trailing edges and special blade tip to break up turbulence and noise. Compressor sound blankets shall also be provided. Refer to drawings for additional requirements.

D. Each circuit shall have fan cycling of at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 45ºF.

E. Evaporative Condensing Option: In lieu of an air-cooled condenser provide the unit with an evaporative condenser module as the outdoor section of the unit.

1. Coils to consist of two 5/16" O.D. 0.022 wall thickness serpentine copper coils.
2. Housing Construction: Evaporative condensing basin, corner posts and roof are to be constructed with 304 stainless steel. The water basin is to be lined with a FRP coating.
3. Water Control: The water movement devices consist of a sump pump for water distribution on the coils, float switches to maintain the water level in the sump, fill and drain valves to fill and drain the sump as required.
4. Water Treatment: Unit to be prepiped with water treatment system and conductivity controller.

F. Compressors

1. Each unit shall have multiple, heavy-duty scroll compressors as required to meet the capacity. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.
2. Multiple Fixed Speed Scroll Compressors
    a. Each unit shall have multiple, heavy-duty scroll compressors. Each compressor shall be complete with crankcase heater, sight-glass, anti-slug protection, current sensing and motor temperature sensing, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.

3. Combination of Fixed Speed and Variable Speed Inverter Compressors
    a. Each unit shall have a variable speed inverter compressor on one circuit and multiple compliant fixed speed scroll compressors on the other. All compressors shall be isolated with resilient rubber isolators to decrease noise transmission. The lead compressor shall be driven by variable frequency drive to control compressor speed. The compressor speed shall dynamically vary to match the space load.
    b. The minimum unit capacity as a percent of full load shall be 20%, or less.
    c. The variable speed inverter compressor motor shall be a brushless permanent magnet type, to provide higher efficiency at all speeds. Oil injection system shall be provided to ensure optimal efficiencies. Oil Strainer shall be provided to control the risk of system debris in the oil injection circuit. Each compressor shall include crankcase heater, sight-glass, anti-slug protection, current sensing and motor temperature sensing, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure.

G. Refrigeration Controls

1. Each unit shall have a minimum of two independent refrigeration circuits. Each circuit shall be complete with a liquid line solenoid valve, low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, liquid line shutoff valve with charging port, discharge line shutoff valve, a manual reset high pressure safety switch, high pressure relief device and pump down switch. The thermal expansion valve shall be

capable of modulation through the entire capacity range. Sight-glasses shall be accessible for viewing without disrupting unit operation. Each refrigerant circuit shall include a subcooling circuit.

H. Refrigeration Capacity Control

1. Refrigeration capacity control shall be accomplished by staging of the unit's multiple compressors in combination with modulation of the inverter driver variable speed compressor(s) where specified. To maintain desired temperature control, the unit shall have multiple steps of capacity control for fixed speed compressors and variable capacity for combined fixed and variable compressor arrays.
   a. All compressor capacity staging or modulation shall be controlled by the factory installed main unit control system.
   b. Modulating hot gas reheat shall be factory installed on the lead refrigerant circuit. Hot gas reheat shall include modulating valves, dehumidification control, temperature sensors, all associated piping and be automatically operated by the unit's microprocessor control. Compressors shall be cycled to maintain leaving dew point from the DX coil. Leaving dry bulb reheat temperature control accuracy shall be +/- 0.5°F.

2.16 ROOF CURB

A. Refer schedule and details on drawing for mounting requirements.

B. Where rigid curb is required provide a prefabricated 12-gauge galvanized steel, mounting curb, designed and manufactured by the unit manufacturer, provided for field installation on the roof prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and rail support of the condensing section. Supply and return opening duct frames shall be provided as part of the curb structure allowing duct connections to be made directly to the curb prior to unit arrival. The curb shall be a minimum of 16" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb.

2.17 CONTROLS

A. Each unit shall be equipped with a complete microprocessor based control system. The unit control system shall include all required temperature and pressure sensors, input/output boards, main microprocessor and operator interface. The unit control system shall perform all unit control functions including scheduling, unit and fault diagnostics and safeties. Refer to drawings for sequence of operation. All boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted, wired and tested.

B. The microprocessor shall be a stand-alone controller not dependent on communications with any on-site or remote PC or master control panel. The microprocessor shall maintain existing set points and operate stand alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

C. Provide BACnet or LonTalk communications interface module for direct communication into the BAS network. The BAS system shall be capable of interacting with the individual rooftop controllers in the following ways:

1. Monitor controller inputs, outputs, set points, parameters and alarms.
2. Set controller set points and parameters.
3. Clear alarms.
4. Reset the cooling and heating discharge air temperature set point.
5. Reset the duct static pressure set point.
6. Set the heat/cool changeover temperature.
7. Set the representative zone temperature.

D. The Systems Integrating Contractor shall be responsible for integrating the rooftop unit controls into the BAS control logic and human interface workstations.

E. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. Each digital input and digital output shall be equipped with an LED for ease of service. All field wiring shall be terminated at a separate, clearly marked terminal strip.

F. The microprocessor shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. Each unit shall also have the ability to accept a time schedule via BAS network communications.

G. A unit mounted human interface panel shall include a keypad with the ability to perform setup, diagnostics and service tests. All control settings shall be password protected from changes by unauthorized personnel.

1. The keypad shall provide the following set points as a minimum as required by selected unit options:
   a. Supply, outdoor and space air temperature.
   b. Six control modes including off manual, auto, heat/cool, cool only, heat only, and fan only.
   c. Four occupancy modes including auto, occupied, unoccupied and bypass.
   d. Control changeover based on return air temperature, outdoor air temperature, or space temperature.
   e. Primary cooling and heating set point temperature based on supply or space temperature.
   f. Night setback and setup space temperature.
   g. Cooling and heating deadband.
   h. Cooling and heating supply temperature reset.
   i. High supply, low supply, and high return air temperature alarm limits.
   j. Ambient compressor and heat lockout temperatures.
   k. Compressor interstage timer duration.
   l. Duct and building static pressure.
   m. Economizer changeover.
   n. Current time and date.
   o. Occupied/unoccupied time schedules with allowances for holiday/event dates and duration/

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that mounting surface, e.g. roof, is ready to receive work.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide layout drawings of units, locations and power requirements to electrical installer.

C. Install minimum 30% efficiency air filters in unit during installation phase. Do not operate the unit without filters in place.

D. Mount rooftop unit on:

1. Seismically restrained spring isolating curb. Install with top surface of roof mounting frame level.
2. Or, factory built roof mounting frame. Install with top surface of roof mounting frame level.
3. Or, attached directly to concrete pad at grade level.

E. Install 3" flexible duct connection at inlets and outlets of units.

F. Install condensate drain piping and traps in accordance with manufacturer's instructions, per local code and as shown on the drawings.

1. Install manufacturer provided condensate “air-trap” where provided with each unit. Install trap per manufacturer’s instructions and install condensate piping as required by local code.

G. The controls installer shall install and all wiring associated with control signals into the units and fully coordinate BAS interface.

H. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

I. Install a new set of filters prior to final air balance and substantial completion.

J. For units with evaporative condensing, coordinate unit startup and operation with water treatment. Under no circumstances shall unit be operated without a fully functioning water treatment system. See Section 232500 HVAC Water Treatment.

3.03 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify

fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four-hours travel from the job site.

END OF SECTION 237434

SECTION 238229 - ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 1, and shall include, but not necessarily be limited to, the following:

1. Electric unit heaters

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230900: Building Automation System (BAS) Controls

D. Division 26: Electrical

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
    a. 99 - Standards Handbook
    b. 210 - Laboratory Methods of Testing Fans for Rating [Unit shall bear AMCA Certified Rating Seal]
    c. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
    d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
    e. 500 - Test Method for Louvers, Dampers, and Shutters

2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units

3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
   b. 430 - Central-Station Air-Handling Units

4. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
5. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems

6. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
7. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.

1.05 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect unit against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.08 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.01 ELECTRIC UNIT HEATER

A. Manufacturers

1. Modine, Carrier, Trane, Dimplex, Berko (Marley) or equal.

B. General

1. Factory fabricated fan coil units with electric heating coil of the size, type configuration and capacity as scheduled on the drawings.
2. Unit mounted temperature controls.

C. Unit Casing

1. Unit shall be constructed of formed cold-rolled steel with internal insulation. Insulation shall be attached with adhesive with all exposed edges coated to prevent erosion. All exposed metal inside and out shall be finished with at least one coat of enamel.

D. Fan Assembly

1. Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
2. Motor shall be permanently lubricated.

E. Unit Suspension

1. Manufacturer to provide factory welded mounting brackets and clips for suspension of units.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work.

C. Install unit supported by brackets provided by manufacturer.

D. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

END OF SECTION 238229