PART 1 - GENERAL REQUIREMENTS

1.01 DESCRIPTION OF WORK

A. This Division requires the furnishing and installing of complete functioning systems, and each element thereof, as specified or indicated on the Drawings and Specifications or reasonably inferred; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include materials, labor, supervision, supplies, equipment, transportation, and utilities.

B. Division 23 of the Specifications and Drawings numbered with prefixes M, MP or ME, or MEP generally describe these systems, but the scope of the Mechanical work includes all such work indicated in the Contract Documents: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.

C. The Drawings have been prepared diagrammatically intended to convey the scope of work, indicating the intended general arrangement of the equipment, fixtures, ductwork, piping, etc. without showing all the exact details as to elevations, offsets, control lines, and other installation requirements. The Contractor shall use the Drawings as a guide when laying out the work and shall verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers requirements, will ensure a complete, coordinated, satisfactory and properly operating system.

1.02 QUALITY ASSURANCE

A. All work under this Division shall be executed in a thorough professional manner by competent and experienced workmen licensed to perform the Work specified.

B. All work shall be installed in strict conformance with manufacturers’ requirements, recommendations, and installation instructions. Equipment and materials shall be installed in a neat and professional manner and shall be aligned, leveled, and adjusted for satisfactory operation.

C. Material and equipment shall be new, shall be of the best quality and design, shall be current model of the manufacturer, shall be free from defects and imperfections and shall have markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Material and equipment of the same type shall be made by the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this project.

1.03 CODES, REFERENCES AND STANDARDS

A. Execute Work in accordance with the National Fire Protection Association and all Local, State, and National codes, ordinances and regulations in force governing the particular class of Work involved. Obtain timely inspections by the constituted authorities, and upon final completion of the Work obtain and deliver to the Owner executed final certificates of acceptance from the Authority Having Jurisdiction.

B. Any conflict between these Specifications and accompanying Drawings and the applicable Local, State and Federal codes, ordinances and regulations shall be reported to the Architect in sufficient time, prior to the opening of Bids, to prepare the Supplementary Drawings and Specification Addenda required to resolve the conflict.

C. The governing codes are minimum requirements. Where these Drawings and Specifications exceed the code requirements, these Drawings and Specification shall prevail.

D. All material, manufacturing methods, handling, dimensions, method or installation and test procedure shall conform to but not be limited to the following industry standards and codes:

BOCA	Building Officials Code Administration
IBC	International Building Code
IMC	International Mechanical Code
IPC	International Plumbing Code
IECC	International Energy Conservation Code
IFC	International Fire Code
IFGC	International Fuel Gas Code
ADA	American Disabilities Act
ADC	Air Diffusion Council
AEC	Arkansas Energy Code for New Building Construction Supplements and Amendments
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
AHRI	Air Conditioning, Heating and Refrigeration Institute
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society of Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
ETL	Electrical Testing Laboratories
HI	Hydraulic Institute
MSS	Manufacturer’s Standardization Society of the Valve and Fitting Industry

NBFU	National Board of Fire Underwriters
NEC	National Electrical Code
NFPA	National Fire Protection Association
NEMA	National Electrical Manufactures' Association
OSHA	Occupational Safety and Health Act
PDI	Plumbing and Drainage Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
UL	Underwriter's Laboratories

E. Contractor shall comply with rules and regulations of public utilities and municipal departments affected by connections of services.

F. All mechanical work shall be performed in compliance with applicable safety regulations, including OSHA regulations. Safety lights, guards, shoring and warning signs required for the performance of the mechanical work shall be provided by the Contractor.

1.04 DEFINITIONS

A. General:

1. Furnish: The term “furnish” is used to mean “supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar operations.”
2. Install: The term “install” is used to describe operations at the project site including the actual “unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.”
3. Provide: The term “provide” means “to furnish and install, complete and ready for the intended use. When ‘furnish’, ‘install’, ‘perform’, or ’provide’ is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, “provide” is implied.
4. Furnished by Owner or Furnished by Others: The item will be furnished by the Owner or Others. It is to be installed and connected under the requirements of this Division, complete and ready for operation, including items incidental to the Work, including services necessary for proper installation and operation. The installation shall be included under the guarantee required by this Division.
5. Engineer: Where referenced in this Division, “Engineer” is the Engineer of Record and the Design Professional for the Work under this Division, and is a Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the “Architect”.
6. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
7. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the

Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other listed Manufacturers and models that meet the specified criteria.

8. Substitution: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Substitutions include Value Engineering proposals.

    a) Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
    b) Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

9. Value Engineering: A systematic method to improve the "value" of goods and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. The goal of VE is to achieve the desired function at the lowest overall cost consistent with required performance.

B. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.

C. The following definitions apply to excavation operations:

1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
2. Bedding: Bedding as used in this section refers to the compacted sand or pea gravel installed in the bottom of a trench to immediately support and cover a pipe or duct.
3. Subbase: as used in this Section refers to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
4. Subgrade: as used in this Section refers to the compacted soil immediately below the slab or pavement system.
5. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Architect.
6. Building Fill: Building fill as used in this section refers to borrowed fill material of rock 1" and larger used to fill foundation excavations

1.05 COORDINATION

A. The Contractor shall visit the site and ascertain the conditions to be encountered while installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provision for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, incorrect or faulty installation of Work under this Division or for additional compensation for Work covered by this Division.

B. The Contractor shall refer to Drawings of the other disciplines and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. The Contractor shall make offsets required to clear equipment, beams and other structural members; and to facilitate concealing piping and ductwork in the manner anticipated in the design.

C. The Contractor shall confirm and coordinate the final location and routing of all mechanical, electrical, plumbing, fire protection, control and audio-visual systems with all architectural features, structural components, and other trades. The contractor shall locate equipment, components, ductwork, piping, conduit, and related accessories to maintain the desired ceiling heights as indicated on the architectural drawings. The contractor shall inform the architect of any areas where conflicts may prevent the indicated ceiling height from being maintained. The contractor shall not proceed with any installation in such areas until the architect has given written approval to proceed or has provided modified contract drawings or written instructions to resolve the apparent conflict.

D. The Contractor shall provide materials with trim which will fit properly the types of ceiling, wall, or floor finishes actually installed.

E. The Contractor shall maintain a foreman on the jobsite at all times to coordinate the work with other contractors and subcontractors so that various components of the mechanical systems will be installed at the proper time, will fit the available space, and will allow proper service access to the equipment. Carry on the Work in such a manner that the Work of the other contractors and trades will not be handicapped, hindered, or delayed at any time.

F. Work of this Division shall progress according to the "Construction Schedule" as established by the Prime Contractor and their subcontractors and as approved by the Architect. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of schedule dates.

1.06 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to the requirements of individual Sections. Additionally, prepare coordination drawings as required scope of installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one trade.

1. Information shall be project specific and drawn accurately to a scale large enough to resolve conflicts. Do not base coordination drawings on standard dimensional data.
2. Prepare floorplans, sections, elevations, and details as needed to adequately describe relationship of various systems and components.
3. Clearly indicate functional and spatial relationships of components of all systems specified in the Contract Documents, including but not limited to: architectural, structural, civil, mechanical, electrical, fire protection, and specialty systems.
4. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
5. Show location and size of access doors required for access to concealed equipment, fittings, controls, terminations, and cabling.
6. Indicate required installation sequence to minimize conflicts between entities.
7. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Contract Administrator indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
8. The details of the coordination are the responsibility of the Contractor and, where indicated on the Drawings, minor adjustments in raceway routing, device placement, device type, or equipment arrangement are not to be considered changes to the Contract.

B. Equipment Room Coordination Drawings: In accordance with the submittal procedures outlined within these Specifications, provide dimensioned layouts of electrical equipment locations within electrical rooms/closets, mechanical rooms, generator rooms, and fire pump rooms with equipment drawn to scale and identified therein.

1. Clearly identify all required working clearances and access provisions required for installation and maintenance.
2. Equipment layouts should be arranged accounting for considerations for required door openings and the clearances required by the equipment manufacturer.
3. Indicate path to allow for the future removal of each large piece of equipment (up to and including generators and unit sub-station transformers) without removal of non-related equipment or architectural elements.
4. Include work provided by others routed through the equipment rooms.

C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.
2. BIM File Incorporation: Develop and incorporate coordination drawing files into Building Information Model established for Project.

    a) Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Contract Administrator.

3. Where Henderson Engineer's digital data files are provided to the Contractor for use in preparing coordination digital data files, Henderson Engineers makes no representations as to the accuracy or completeness of digital data files as they relate to the Drawings or Specifications.
4. Submit coordination drawings in accordance with the submittal procedures outlined within these Specifications.

1.07 MEASUREMENTS AND LAYOUTS

A. The drawings are schematic in nature, but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the building. Figured dimensions shall be taken in preference to scale dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing the Contract Documents. The Contractor will be held responsible for errors which could have been avoided by proper checking and inspection.

1.08 SUBMITTALS

A. Refer to Division 01 and General Conditions for submittal requirements in addition to requirements specified herein.

B. Refer to Division 01 for acceptance of electronic submittals. If not specified by Division 01, provide electronic submittals. If Division 01 requires paper submittals, provide the quantity of submittals required, but no fewer than seven (7) sets.

C. For electronic submittals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Contract Administrator and Engineer that the submittals have been posted. If electronic submittal procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the submittals. For submittals sent by e-mail, Contractor shall copy the Contract Administrator's and Engineer's designated representatives. Contractor shall allow for the Engineer Review Time as specified. Contractor shall submit only the documents required to purchase the materials and/or equipment in the submittal.

D. Engineer Review Time: Transmit submittals as early as required to support the project schedule. Allow two weeks for Engineer review time plus to/from mailing time via the Contract Administrator, plus a duplication of this time for resubmittal if required. Transmit submittals as soon as possible after Notice to Proceed and before Mechanical construction starts.

E. Submittals and shop drawings shall not contain the firm name, logo, seal, or signature of the Engineer. They shall not be copies of the work product of the Engineer. If the Contractor desires to use elements of such product, the license agreement for transfer of information obtained from the Engineer must be used.

F. Assemble and submit for review manufacturer product literature for material and equipment to be furnished and/or installed under this Division. Literature shall include shop drawings, manufacturer product data, performance sheets, samples, and other submittals required by this Division as noted in each individual Section. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.

G. Separate submittals according to individual specification sections. Only resubmit those sections requested for resubmittal.

H. Provide submittals in sufficient detail so as to demonstrate compliance with these Contract Documents and the design concept. Highlight, mark, list or indicate the materials, performance criteria and accessories that are being proposed. Illegible submittals will be rejected and returned without review.

I. Refer to individual Sections for additional submittal requirements.

J. Before transmitting submittals and material lists, verify that the equipment submitted is mutually compatible with and suitable for the intended use. Verify that the equipment will fit the available space and maintain manufacturer recommended service clearances. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.

K. Submittals shall contain the following information:

1. The project name.
2. The applicable specification section and paragraph.
3. Equipment identification acronym as used on the drawings.
4. The submittal date.
5. The Contractor's stamp, which shall certify that the stamped drawings have been checked by the Contractor, comply with the Drawings and Specifications, and have been coordinated with other trades.
6. Submittals not so identified will be returned to the Contractor without action.

L. The checking and subsequent acceptance by the Engineer and/or Contract Administrator of submittals shall not relieve responsibility from the Contractor for (1) deviations from Drawings and Specifications; (2) errors in dimensions, details, sizes of equipment, or quantities; (3) omissions of components or fittings; and (4) not coordinating items with actual building conditions and adjacent work. Contractor shall request and secure written acceptance from the Engineer and Contract Administrator prior to implementing any deviation.

M. Provide welders' qualification certificates.

N. BIM Incorporation: Develop and incorporate Shop Drawing files into BIM established for Project.

1.09 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF format from the Engineer for a shipping and handling fee of $200 for a drawing set up to 12 sheets and $15 per sheet for each additional sheet. Contact the Architect for Architect's written authorization. Contractor shall request and complete the Electronic File Release Agreement form from the Engineer. Send the form along with a check made payable to Henderson Engineers, Inc. Contractor shall indicate the desired shipping method and drawing format on the attached form. In addition to payment, Architect's written authorization and Engineer's release agreement form must be received before electronic drawing files will be sent.

1.010 SUBSTITUTIONS

A. Refer to Division 01 and General Conditions for Substitutions in addition to requirements specified herein.

B. Materials, products, equipment, and systems described in the Bidding Documents establish a standard of required function, dimension, appearance and quality to be met by the proposed substitution.

C. The base bid shall include only the products from manufacturers specifically named in the drawings and specifications.

D. Request for Substitution:

1. Complete and send the Substitution Request Form attached at the end of this section for each material, product, equipment, or system that is proposed to be substituted.
2. The burden of proof of the merit of the proposed substitution is upon the proposer.
3. Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner the following:

a) Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
b) Proposed substitution is consistent with the Contract Documents and will produce indicated results, including functional clearances, maintenance service, and sourcing of replacement parts.
c) Proposed substitution has received necessary approvals of authorities having jurisdiction.
d) Same warranty will be furnished for proposed substitution as for specified Work.
e) If accepted substitution fails to perform as required, Contractor shall replace substitute material or system with that originally specified and bear costs incurred thereby.
f) Coordination, installation and changes in the Work as necessary for accepted substitution will be complete in all respects.

E. Substitution Consideration:

1. No substitutions will be considered unless the Substitution Request Form is completed and attached with the appropriate substitution documentation.
2. No substitutions will be considered prior to receipt of Bids unless written request for approval to bid has been received by the Engineer at least ten (10) calendar days prior to the date for receipt of Bids.
3. If the proposed substitution is approved prior to receipt of Bids, such approval will be stated in an Addendum. Bidders shall not rely upon approvals made in any other manner. Verbal approval will not be given.
4. No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.011 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 and General Conditions for Operation and Maintenance Manuals in addition to requirements specified herein.

B. Submit manuals prior to requesting the final punch list and before all requests for Substantial Completion.

C. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.

D. Prior to Substantial Completion of the project, furnish to the Architect, for Engineer’s review, and for the Owner’s use, four (4) copies of Operation and Maintenance Manuals in labeled, hard-back three-ring binders, with cover, binding label, tabbed dividers and plastic insert folders for Record Drawings. Include local contacts, complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.

E. Each manual shall contain data listed in each individual Section.

F. Refer to Division 01 for acceptance of electronic manuals for this project. For electronic manuals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Architect and Engineer that the manuals have been posted. If electronic manual procedures are not defined in Division 01, Contractor shall include the website, user name and password information needed to access the manuals. For manuals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representative.

1.012 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections in Division 23 of this specification.

1.013 RECORD DRAWINGS

A. Refer to Division 01 and General Conditions for Record Drawings in addition to requirements specified herein.

B. A set of work prints of the Contract Documents shall be kept on the jobsite during construction for the purpose of noting changes. During the course of construction, the Contractor shall indicate on these Documents changes made from the original Contract Documents. Particular attention shall be paid to those items which need to be located for servicing. Underground utilities shall be located by dimension from column lines.

C. At the completion of the project, the Contractor shall obtain, at their expense, reproducible copies of the final drawings and incorporate changes noted on the jobsite work prints onto these drawings. These changes shall be done by a skilled drafter. Each sheet shall be marked "Record Drawing", along with the date. These drawings shall be delivered to the Architect/Engineer.

1.014 TRAINING

A. Provide training as indicated in each specific section. Schedule training with the Owner at least 7 days in advance. Video record the training sessions in format as agreed to with the Owner. Provide three copies of each session to the Owner and obtain written receipt from the Owner.

1.015 PAINTING

A. Exposed ductwork and ferrous surfaces, including pipe, pipe hangers, equipment stands and supports and exposed insulated piping shall be painted by the Contractor using materials and methods as specified under Division 09 of the Specifications; colors shall be as selected by the Architect.

B. Factory finishes, shop priming and special finishes are specified in the individual equipment specification sections.

C. Where factory finishes are provided and no additional field painting is specified, marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish.

1.016 DELIVERY, STORAGE AND HANDLING

A. Refer to Division 01 and General Conditions for Delivery, Storage and Handling in addition to requirements specified herein.

B. Equipment and material shall be delivered to the job site in their original containers with labels intact, fully identified with manufacturer's name, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.

C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, to include the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which become rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Architect.

D. The Contractor shall be responsible for the safe storage of their own tools, material and equipment.

1.017 GUARANTEES AND WARRANTIES

A. Refer to Division 01 and General Conditions for Guarantees and Warranties in addition to requirements specified herein.

B. Each system and element thereof shall be warranted against defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific items are noted to carry a longer warranty in the Construction Documents or manufacturer's standard warranty. The Contractor shall remedy defects occurring within a period of one year from the date of Substantial Completion or as stated in the General Conditions.

C. The following additional items shall be guaranteed:

1. Piping shall be free from obstructions, holes or breaks of any nature.
2. Insulation shall be effective.
3. Proper circulation of fluid in each piping system.

D. The above guarantees shall include both labor and material; and repairs or replacements shall be made without additional cost to the Owner.

E. The remedial work shall be performed promptly, upon written notice from the Architect or Owner.

F. At the time of Substantial Completion, deliver to the Owner warranties with terms extending beyond the one year guarantee period, each warranty instrument being addressed to the Owner and stating the commencement date and term.

1.018 TEMPORARY FACILITIES

A. Refer to Division 01 and General Conditions for Temporary Facilities requirements in addition to requirements specified herein.

B. Temporary Utilities: The types of services required include, but are not limited to, water, sewerage, surface drainage and gas. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.

1. Provide the necessary backflow prevention devices where connecting to the potable water system. Protect water service from freezing by draining system or by providing adequate heat. Where non-potable water is used, mark each outlet with health hazard warning signs.
2. Sewer Sediment: Maintain sewers and temporary connecting sewers in a clean, non-clogged condition during construction period.

C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.

1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.
2. Heating: Provide heat, as necessary, to protect work, materials and equipment from damage due to dampness and cold. In areas where building is occupied, maintain a temperature not less than 65 degrees Fahrenheit. Use steam, hot water, or gas from piped distribution system where available. Where steam, hot water or piped gas are not available, heat with self-contained LP gas or fuel oil heaters, bearing UL, FM or other approval labels appropriate for application. Vent fuel-burning heaters, and equip units with individual-space thermostatic controls. Use electric-resistance space heaters only where no other, more energy-efficient, type of heater is available and allowable.

1.019 PROJECT CONDITIONS

A. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

2.01 SOIL MATERIALS

A. Bedding Material: Provide clean sand, pea gravel or flowable fill material (per the geotechnical or structural engineer's recommendations).

B. Subbase Material: Where applicable, provide natural soils with 10% by volume of rocks less than 2" diameter or artificially graded crushed aggregate. Corrosive fill materials shall be not be utilized. When CL clay, rock, or gravel is used, it shall not be larger than 2 inches in any dimension and shall be free of debris, waste, frozen materials, vegetable and other deleterious matter.

C. Filter Fabric: Flat needle punched PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

PART 3 - EXECUTION

3.01 PERMITS

A. Secure and pay for permits required in connection with the installation of the Mechanical Work. Arrange with the various utility companies for the installation and connection of required utilities for this facility and pay charges associated therewith including connection charges and inspection fees, except where these services or fees are designated to be provided by others.

3.02 EXISTING UTILITIES

A. Schedule and coordinate with the Utility Company, Owner and with the Engineer connection to, or relocation of, or discontinuation of normal utility services from existing utility lines. Premium time required for any such work shall be included in the bid.

B. Existing utilities damaged due to the operations of utility work for this project shall be repaired to the satisfaction of the Owner or Utility Company without additional cost.

C. Utilities shall not be left disconnected at the end of a work day or over a weekend unless authorized by representatives of the Owner or Engineer.

D. Repairs and restoration of utilities shall be made before workmen leave the project at the end of the workday in which the interruption takes place.

E. Contractor shall include in their bid the cost of furnishing temporary facilities to provide services during interruption of normal utility service.

3.03 EXCAVATION AND BACKFILLING

A. Refer to Division 01, Division 02, and Division 31, Geotechnical Soils Report and General Conditions for Excavation and Backfilling in addition to the requirements specified herein.

B. Perform excavation of every description, of whatever substance encountered and to the depth required in connection with the installation of the work under this Division. Excavation and Trenching shall be in conformance with applicable Division and section of the General Specifications.

C. Roads, alleys, streets and sidewalks damaged during this work shall be restored to the satisfaction of Authorities Having Jurisdiction.

D. Trenches close to walks or columns shall not be excavated without prior consultation with the Architect.

E. Erect barricades around excavations and trenches for safety. Provide an adequate number of amber lights on or near the work and keep them burning from dusk to dawn. Contractor shall be held responsible for any damage that any parties may sustain due to neglecting the necessary precautions when performing the work.

F. Slope sides of excavations and trenches to comply with Geotechnical Report, local, state and federal codes and ordinances. Shore and brace as required for stability of excavation.

G. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local, state and federal codes and authorities. Maintain shoring and bracing in excavations and trenches regardless of time period excavations and trenches will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.

H. Install sediment and erosion control measures in accordance with local codes and ordinances.

I. Dewatering of Excavation and Trenches: Prevent surface water and subsurface or ground water from flowing into excavations and trenches.

1. Do not allow water to accumulate in excavation or trenches. Remove water to prevent softening of bearing materials. Provide and maintain dewatering

system components necessary to convey water away from excavations and trenches.

2. Establish and maintain temporary drainage ditches and other diversions outside excavation and trench limits to convey surface water to collecting or run-off areas.
3. Do not use trench excavations as temporary drainage ditches. In no case shall sewers be used as drains for such water.

J. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations and trenches. Do not store within drip-line of trees indicated to remain.
2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

K. Trenching: Excavate trenches as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of pipe and equipment.
2. Excavate trenches to depth indicated or required to establish indicated slope and invert elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.
3. Limit the length of open trench to that in which pipe can be installed, tested, and the trench backfilled within the same day.
4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of sand or pea gravel prior to installation of pipe. Provide a minimum of 6 inches of sand or pea gravel cushion between rock bearing surface and pipe.
5. Excavate trenches for piping and equipment with bottoms of trench to accurate elevations for support of pipe and equipment bedding on undisturbed soil.

L. Cold Weather Protection: Protect excavation and trench bottoms against freezing when atmospheric temperature is less than 35°F.

M. Bedding:

1. Fill bottom of pipe trench and fill unevenness with compacted bedding material to ensure continuous bearing of the pipe barrel on the bearing surface. Additional bedding installation requirements are in the following piping specifications. Compact bedding as described below.
2. Fill bottom of equipment trench and fill unevenness with compacted sand backfill to ensure continuous bearing of the equipment on the bearing surface. Compact bedding as described below.

N. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under pipes, use bedding materials in layers to 6 inches above top of the pipe.
2. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
3. Under building slabs, use subbase materials.
4. Under piping and equipment, use bedding and subbase materials over rock bearing surface and for correction of unauthorized excavation.
5. For piping less than 30 inches below surface of roadways, provide 4-inch-thick concrete protection slab. After installation and testing of pipes, provide a 4-inch thick concrete protection top slab prior to backfilling and placement of roadway subbase. Contractor shall coordinate with local AHJ as to requirements for colored concrete in this application.
6. Other areas, use excavated or borrowed materials where applicable.
7. Backfill excavations as promptly as work permits, but not until completion of the following:

   a) Inspection, testing, approval, and locations of underground utilities have been recorded.
   b) Removal of concrete formwork.
   c) Removal of shoring and bracing, and backfilling of voids.
   d) Removal of trash and debris.

8. Where gravel fill (drainage fill) is used as building fill material in lieu of natural soils, provide filter fabric material to line the trench to support the bedding fill material and subgrade materials to ensure that backfill materials will not segregate within the trench nor create voids and sags within the pipe trench.

O. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

P. Subgrade Placement and Compaction: Place subgrade backfill materials in maximum layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

Q. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

R. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of piping and equipment by carrying material uniformly around them to approximately same elevation in each lift.

S. Placement and Compaction: Place bedding backfill materials in maximum layers of not more than 6 inches loose depth for material compacted by hand-operated tampers. Place subbase backfill materials in maximum layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers. Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

1. Use of pneumatic backhoe as compaction method is disallowed as an acceptable process for compaction of excavations or trenches.
2. For vertical and/or diagonal pipe installations greater than ½" rise/lf, thoroughly support pipes from permanent concrete structures or undisturbed earth at no less than 10-foot intervals, while placing backfill materials, so that pipes are not deflected, crushed, broken, or otherwise damaged by the backfill placement or settlement.
3. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
4. Place backfill and/or drainage fill materials evenly adjacent to structures, piping, and equipment to required elevations. Coordinate with Architect and/or Civil Engineer backfill requirements prior to installation. Prevent displacement of pipes and equipment by carrying material uniformly around them to approximately same elevation in each layer or lift.
5. Compaction: control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below:
6. Percentage of maximum density requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 or ASTM D 698 and not less than the following percentages of relative density, determined in accordance with ASTM D 4253, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

    a) Areas under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent maximum density for cohesive material listed, or 95 percent relative density for cohesionless material.

b) Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 95 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.

c) Other Areas: Compact top 6 inches of subgrade and each layer of subbase backfill or fill material to 90 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

T. Subsidence: Where subsidence occurs at mechanical installation excavations and trenches during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.04 CLEANING

A. Dirt and refuse resulting from the performance of the work shall be removed from the premises as required to prevent accumulation. The Mechanical Contractor shall cooperate in maintaining reasonably clean premises at all times.

B. Immediately prior to the final inspection, the Mechanical Contractor shall clean material and equipment installed under the Mechanical Contract. Dirt, dust, plaster, stains, and foreign matter shall be removed from surfaces including components internal to equipment. Damaged finishes shall be touched-up and restored to their original condition.

3.05 SUBSTANTIAL COMPLETION REVIEW

A. Prior to requesting inspection for "CERTIFICATE OF SUBSTANTIAL COMPLETION", the Contractor shall complete the following items:

1. Submit complete Operation and Maintenance Manuals.
2. Submit complete Record Drawings.
3. Perform special inspections as required in each individual Section.
4. Start-up testing of systems.
5. Removal of temporary facilities from the site.
6. Comply with requirements for Substantial Completion in the "General Conditions".

B. The Contractor shall request in writing a review for Substantial Completion. The Contractor shall give the Architect/Engineer at least seven (7) days notice prior to the review.

C. The Contractor's written request shall state that the Contractor has complied with the requirements for Substantial Completion.

D. Upon receipt of a request for review, the Architect/Engineer will either proceed with the review or advise the Contractor of unfulfilled requirements.

E. If the Contractor requests a site visit for Substantial Completion review prior to completing the above mentioned items, the Contractor shall reimburse the Architect/Engineer for time and expenses incurred for the visit.

F. Upon completion of the review, the Architect/Engineer will prepare a "final list" of outstanding items to be completed or corrected for final acceptance.

G. Omissions on the "final list" shall not relieve the Contractor from the requirements of the Contract Documents.

H. Prior to requesting a final review, the Contractor shall submit a copy of the final list of items to be completed or corrected. The Contractor shall state in writing that each item has been completed, resolved for acceptance or the reason it has not been completed.

END OF SECTION

SUBSTITUTION REQUEST FORM

To Project Engineer: ____________________ Request # (GC Determined): ______________

Project Name: ____

Project No/Phase: _________________________ Date: _______________________________

Specification Title: ____

Section Number: ______________________ Page: ___________ Article/Paragraph: __________

Proposed Substitution: ____

____

Manufacturer: _____________________________ Model No.: ____________________________

Address: __________________________________ Phone: ________________________________

History: ☐ New product ☐ 1-4 years old ☐ 5-10 years old ☐ More than 10 years old

Differences between proposed substitution and specified Work: ______________________________

____

☐ Point-by-point comparative data attached – REQUIRED BY ENGINEER
Comparative data may include but not be limited to performance, certifications, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements. Include all information necessary for an evaluation.

Supporting Data Attached: ☐ Drawings ☐ Tests ☐ Product Data ☐ Reports ☐ Samples ☐ Other: __________

Reason for not providing specified item: ____

____

Similar Installation:

Project: __________________________ Architect: ______________________________

Address: __________________________ Owner: _________________________________

__________________________ Date Installed: __________________________

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain: __________________

____

____

Substitution Certification Statement:

Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner that the:

A. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
B. Proposed substitution is consistent with the Contract Documents and will produce indicated results.
C. Proposed substitution does not affect dimensions and functional clearances.
D. Proposed substitution has received necessary approvals of authorities having jurisdiction.
E. Same warranty will be furnished for proposed substitution as for specified Work.
F. Same maintenance service and source of replacement parts, as applicable, is available.
G. Proposed substitution will not adversely affect other trades or delay construction schedule.
H. Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

______________________	______	______________________
Submitting Contractor	Date	Company

Manufacturer's Certification of Equal Quality:

I ____________________________ represent the manufacturer of the Proposed Substitution item and hereby certify and warrant to Architect, Engineer, and Owner that the function and quality of the Proposed Substitution meets or exceeds the Specified Item.

______________________	______	______________________
Manufacturer's Representative	Date	Company

Engineer Review and Recommendation Section

Recommend Acceptance	☐ Yes	☐ No
Additional Comments:	☐ Attached	☐ None

Acceptance Section:

Contractor Acceptance Signature	Date	Company
Owner Acceptance Signature	Date	Company
Architect Acceptance Signature	Date	Company
Engineer Acceptance Signature	Date	Company

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment. These components include, but are not limited to factory furnished motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

C. System shall be complete and operational with power and control wiring provided to meet the design intent shown on the drawings and specified within the specification sections.

1.02 SUBMITTALS

A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification Sections.

1.03 QUALITY ASSURANCE

A. Electrical components and materials shall be UL labeled.

B. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of this Section and Division 26.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL

A. The Contractors shall provide all motors, starters, disconnects, wire, conduit, etc. as specified in the Construction Documents. If, however, the Division 23 Contractor furnishes a piece of equipment requiring a different motor, starter, disconnect, wire size, etc. than what is shown and/or intended on the Construction

Documents, this Contractor shall coordinate the requirements with any other Contractor and shall be responsible for any additional cost incurred by any other Contractor that is associated with installing the different equipment and related accessories for proper working condition.

B. Refer to Division 26, "COMMON WORK RESULTS FOR ELECTRICAL" for specification of motor connections.

C. Refer to Division 26, "ENCLOSED CONTROLLERS" for specification of motor starters.

D. Refer to Division 26, "ENCLOSED SWITCHES AND CIRCUIT BREAKERS" for specification of disconnect switches and enclosed circuit breakers.

PART 3 - EXECUTION

3.01 CONTRACTOR COORDINATION

A. Unless otherwise indicated, all motors, equipment, controls, etc. shall be furnished, set in place and wired in accordance with Table 1. Any items not listed but shown on the drawings shall be considered part of the Contract Documents and brought to the attention of the Architect.

B. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Engineer.

TABLE 1: ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

ITEM	FURN BY	SET BY	POWER WIRING	CONTROL WIRING
Equipment motors	DIV23m	DIV23m	DIV26	---
Motor control centers	DIV26	DIV26	DIV26	DIV23t
Factory furnished motor starters contactors and disconnects	DIV23m	DIV23m	DIV26	DIV23t
Overload heaters	DIV23m	DIV26	---	---
Loose motor starters, disconnect switches, thermal overloads and heaters.	DIV26	DIV26	DIV26	DIV23t
Variable speed drives	DIV23m	DIV23m	DIV26	DIV23t
Manual operating multi-speed switches	DIV23m	DIV26	DIV26	DIV23t
Control relays	DIV23t	DIV23t	DIV26	DIV23t
Thermostats (low voltage)	DIV23t	DIV23t	---	DIV23t
Thermostats (line voltage)	DIV23m	DIV23m	DIV26	---
Time switches (for mechanical equipment)	DIV23t	DIV23t	DIV26	DIV23t
Control power transformers	DIV23t	DIV23t	DIV26	DIV23t
Control power transformers furnished with equipment	DIV23m	DIV23m	DIV26	DIV23t
Temperature control panels (housing controllers)	DIV23t	DIV23t	DIV26	DIV23t
Building controllers, advanced application controllers, and application specific controllers	DIV23t	DIV23t	DIV23t	DIV23t
Motor and solenoid operated valves	DIV23t	DIV23m	DIV23t	DIV23t
Presssure independent control valves	DIV23t	DIV23m	DIV23t	DIV23t
Damper operators, PE & switches	DIV23t	DIV23t	DIV23t	DIV23t
Smoke dampers and combination fire/smoke dampers	DIV23m	DIV23m	DIV26	DIV28
Smoke dampers for smoke control system	DIV23t	DIV23m	DIV26	DIV23t/28
Duct Smoke detectors	DIV28	DIV23m	DIV28	DIV28
Refrigeration equipment and controls	DIV23m	DIV23m	DIV26	DIV23t
Pushbutton stations and connections	DIV23m	DIV23m	DIV26	DIV23t
Temporary heating connections	DIV23m	DIV23m	DIV26	DIV23m
Interlocks between kitchen exhaust hood(s)	---	---	---	DIV23m

DIV23m = Mechanical Contractor
DIV23t = Temperature Controls Sub-Contractor
DIV26 = Electrical Contractor
DIV28 = Electronic Safety and Security

END OF SECTION

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PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with mechanical installations as follows:

1. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.
2. Mechanical equipment nameplate data.
3. Concrete for bases and housekeeping pads.
4. Non-shrink grout for equipment installations.
5. Sleeves for mechanical penetrations.
6. Drip Pans with detection.
7. Miscellaneous metals for support of mechanical materials and equipment.
8. Wood grounds, nailers, blocking, fasteners, and anchorage for support of mechanical materials and equipment.
9. Joint sealers for sealing around mechanical materials and equipment.
10. Sealing penetrations through noise critical spaces.
11. Plenum insulation for enclosure of combustible items located within fire-rated plenums.
12. Firestopping

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 07 Section “Penetration Firestopping” for material and methods for firestopping systems.
2. Division 23 Section "Basic Piping Materials and Methods," for materials and methods for mechanical sleeve seals.
3. Division 23 Section “Direct Digital Controls for HVAC” for integration with building automation system of leak detection system “Water Present” alarm.
4. Division 26 Section “Common Work Results for Electrical” required electrical devices.
5. Division 26 Sections "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.02 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 23 Section General Mechanical Requirements.

1. Product data for the following products:

    a) Access panels and doors.
    b) Joint sealers.
    c) Through and membrane-penetration firestopping systems.
    d) Plenum insulation.

2. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for mechanical materials and equipment.
3. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.
4. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.

    a) Coordinate sequencing with construction phasing and Owner occupancy specified in Division 01 Section "Summary of Work."

5. Through and Membrane Penetration Firestopping Systems Product Schedule: Submit a schedule for each piping system penetration that includes UL listing, location, wall or floor rating and installation drawing for each penetration fire stop system.

    a) Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.03 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

    1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

    1. Provide UL Label on each fire-rated access door.

C. Through and Membrane Penetration Firestopping Systems Installer Qualifications: A firm experienced in installing penetration firestopping systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping system products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

1.04 NOISE CRITICAL SPACES

A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces; noise levels due to equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall permit attaining sound pressure levels in all 8 octave bands in occupied spaces conforming to RC levels per ASHRAE handbook as indicated.

Space	RC Levels
Theatre	25
Teleconference Rooms	25
Meeting/Banquet Rooms	30
Clinic Exam Rooms	30
Conference Rooms	30
Classrooms	30
Library	25
Offices	30
Open Offices	40
Study Areas	30

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCESS TO EQUIPMENT

A. Refer to Architectural documents for specification of Access Panels and Access Doors.

2.02 MECHANICAL EQUIPMENT NAMEPLATE DATA

A. For each piece of power operated mechanical equipment, provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance's, and similar essential data. Locate nameplates in an accessible location.

2.03 CONCRETE EQUIPMENT BASES/HOUSEKEEPING PADS

A. Provide concrete equipment bases and housekeeping pads for various pieces of floor mounted mechanical equipment. Concrete equipment bases/housekeeping pads shall generally conform to the shape of the piece of equipment it serves with a minimum 4" margin around the equipment and supports.

B. Form concrete equipment bases and housekeeping pads using framing lumber or steel channel with form release agent. Chamfer top edges and corners. Trowel tops and sides of each base/pad to a smooth finish, equal to that of the floors.

C. Concrete equipment bases and housekeeping pads shall be made of a minimum 28 day, 4000 psi concrete conforming to American Concrete Institute Standard Building Code for Reinforced Concrete (ACI 318-99) and the latest applicable recommendations of the ACI standard practice manual. Concrete shall be composed of cement conforming to ASTM C 150 Type I, aggregate conforming to ASTM C33, and potable water. All exposed exterior concrete shall contain 5 to 7 percent air entrainment.

D. Unless otherwise specified or shown on the structural drawings, reinforce equipment bases and housekeeping pads with No. 4 reinforcing bars conforming to ASTM A 615 or 6x6 – W2.9 x W2.9 welded wire mesh conforming to ASTM A185. Reinforcing bars shall be placed 24” on center with a minimum of two bars each direction.

E. Provide galvanized anchor bolts for all equipment placed on concrete equipment bases and housekeeping pads or on concrete slabs. Anchor bolts size, number and placement shall be as recommended by the Manufacturer of the equipment.

F. Concrete equipment bases and housekeeping pads shall have height as specified on the drawings or minimum height if not specified in accordance with the following table:

Equipment	Minimum Height
Furnaces, Exterior Equipment Less than or equal to 20 tons and Other Equipment Not Listed	3-1/2”
Air Handling Units w/TSP less than or equal to 3.5”, Boilers (See Note 1)	3-1/2”
Chillers, Condensate Pumps, Base Mounted Pumps up to 30 HP, Air Handling Units w/TSP greater than 3.5”, All Vertical Inline Pumps, (See Note 1)	5-1/2”

NOTES:

1. Height of equipment bases applies to equipment installed on slab-on-grade. For equipment installed on floors above grade and/or roof, reference the drawings.

2. Coordinate final pad heights for air handling units with required condensate trap depths. Increase pad heights as needed to allow for unit trap height and required slope to drain.

2.04 GROUT

A. Provide nonshrink, nonmetallic grout conforming to ASTM C 1107, Grade B, in premixed and factory-packaged containers.

B. Grout shall have post-hardening, volume-adjusting, dry, non-staining, non-corrosive, non-gaseous, hydraulic-cement characteristics and shall be as recommended by manufacturer for interior and exterior applications.

C. Grout shall have 5,000 psi, 28-day compressive strength design mix.

2.05 PENETRATIONS

A. Sleeves:

1. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A-53 grade A or 12 gauge (0.1084 inches) welded galvanized steel formed to a true circle concentric to the pipe.
2. Sheet-Metal Sleeves: 10 gauge (0.1382 inches), galvanized steel, round tube closed with welded longitudinal joint.

B. Frames for rectangular openings attached to forms and of a maximum dimension established by the Architect. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, provide 18 gauge (0.052 inches) welded galvanized steel. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, provide 10 gauge (0.1382 inches) welded galvanized steel. Notify the General Contractor or Architect before installing any box openings not shown on the Architectural or Structural Drawings.

2.06 DRIP PANS

A. Drip pans for pipes in protected areas shall be 20 gauge galvanized steel with 2” lapped and soldered joints. Drip pan shall have a depth of 2” and a width of 6” in addition to the diameter of the associated pipe. Provide 3/4” galvanized pipe with male NPT outlet at low point of drip pan. Connect ¾” type “L” copper indirect drain line to drip pan outlet. Route and discharge to receptor with air gap outside of the protected area.

B. Drip pan supports shall be ¼" X 2" galvanized bar stock welded to the drip pan without holes. Provide ¼" galvanized threaded rods through bar stock on each side of the drip pan and attached with 2 nuts per rod. Attach rods to structure with MSS SP-58 compliant components.

C. Flood Detector: Flood detector switch utilizing hydrophilic pad and stainless steel sensor array to detect moisture. Switch shall be provided with integral feet to prevent pad from contacting the pan. Provide with solid state electronics and double throw relay to allow switch to shut down unit and provide an auxiliary alarm output.

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

a) Diversitech
b) RCT/Aquaguard
c) Approved equivalent

2.07 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Fasteners: Zinc-coated, type, grade, and class as required.

2.08 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less that 15/32 inches.

2.09 JOINT SEALERS

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Nonacid Curing Sealer: One-part, nonacid-curing, silicone sealant complying with ASTM C920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.

1. Manufacturers:

a) Dow Corning, Dowsil 790.
b) Dow Corning, Dowsil 795.
c) GE, Silglaze II SCS 2350.
d) GE, Silpruf SCS 2000.
e) Owens Corning, Energy Complete.
f) Pecora, 864 NST.
g) Tremco, Spectrem 1.
h) Tremco, Spectrem 2.

D. High Humidity Sealer: One-part, mildew-resistant, silicone sealant complying with ASTM C920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.

1. Manufacturers:

a) Dow Corning, Dowsil 786.
b) GE, Momentum SCS1700.
c) Pecora, 898 Silicone NST.

E. Hybrid Joint Sealer: One-part, non-sag, paintable complying with ASTM C920, Type S, Grade NS, Class 50, recommended for exposed applications on interior and exterior locations involving joint movement of not more than plus or minus 50 percent.

1. Manufacturers:

a) BASF, MasterSeal NP 100.
b) Pecora, DyanTrol I-XL.
c) Tremco, Dymonic FC.

F. Acrylic Latex Joint Sealer: One-part, non-sag, mildew-resistant, paintable acrylic latex or siliconized acrylic latex, complying with ASTM C834, Type OP, Grade NF, recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.

1. Manufacturers:

a) Pecora, AC-20
b) Sherwin Williams 950A
c) Tremco, Tremflex 834

2.010 ACOUSTICAL SEALANTS

A. General: Penetrations by ducts, pipes and conduit through surfaces that are around and between noise critical spaces shall be sleeved, packed and sealed airtight with foam rod, non-hardening sealant and/or packing material as described herein.

B. Foam Rod: Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

C. Non-Hardening Sealant: Sealant for penetrations shall be non-hardening. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

D. Packing Material: Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 pcf (40 kg/m3).

E. Acoustical Joint Sealant: Manufacturer's standard non-sag, paintable, non-staining latex sealant complying with ASTM C834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E90. Meeting ASTM E84 for a smoke flame spread index of less than 25 / 50.

F. Manufacturers:

1. Pecora, AC-20 FTR.
2. Pecora, AIS-919.
3. USG, SHEETROCK Acoustical Sealant.

2.011 PLENUM INSULATION

A. General: Combustible materials including, but not limited to, plastic pipe and plastic-coated cables that do not meet the minimum combustibility requirements of the applicable building codes may be installed in fire-rated plenums when enclosed within high-temperature insulation blanket where approved by the authority having jurisdiction.

B. Material: FyreWrap 0.5 Plenum Insulation, ETS Schaefer Plenumshield Blanket, Thermal Ceramics PlenumWrap+, Knauf Earthwool 1000, or equivalent utilizing light weight, high temperature blanket enhanced for biosolubility. The encapsulating material shall be aluminum foil with fiberglass reinforcing scrim covering.

C. Certification: Plenum insulation shall have an encapsulated flame spread rating less than 25 and a smoke developed rating of less than 50. The product shall be UL 1887 (Modified) listed, certified by ASTM E-136 for Non-combustibility and ASTM E-84/UL 723 for Surface Burning Characteristics.

D. Physical Properties: Plenum insulation shall be single 1” minimum layer with a density of 2 to 6 pounds per cubic foot.

2.012 FIRESTOPPING

A. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E814, or other NRTL acceptable to AHJ.

B. Manufacturers:

1. 3M Corp., Fire Barrier Sealant.
2. Hilti.
3. Owens Corning, Firestopping Insulation.
4. Pecora, AC-20 FTR.
5. RectorSeal.
6. Specified Technologies Inc., Firestop.
7. USG SHEETROCK Firecode Compound.
8. Tremco, Tremstop Fyre-Sil.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer’s instructions.

3.02 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.03 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

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

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

3.04 PREPARATION FOR JOINT SEALERS

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.05 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

3.06 PENETRATIONS:

A. New Construction:

1. Coordinate with Divisions 03 and 04 for installation of sleeves and sleeve seals integrally in cast-in-place, precast, and masonry walls and horizontal slabs where indicated on the Drawings or as required to support piping or ductwork penetrations.

B. Provide sleeves and/or box frames for openings in all concrete and masonry construction and fire or smoke partitions, for all mechanical work that passes through such construction; Coordinate with other trades and Divisions to dimension and lay out all such openings.

C. The General Contractor will provide only those openings specifically indicated on the Architectural or Structural Drawings as being provided under the General Contractor's work.

D. The cutting of new or existing construction shall not be permitted except by written approval of the Architect.

E. Floor sleeves shall be fitted with means for attachment to forms and shall be of length to extend at least two inches above the floor level.

F. All sleeves shall be of ample size to allow for movement of conduit, duct or pipe and insulation through the sleeves without damage to the insulation.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors 2 inches above finished floor level.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

J. Seal space outside of sleeves with approved joint compound for penetrations of gypsum board assemblies.

3.07 DRIP PANS

A. Provide drip pans in locations indicated on drawings.

B. Provide drip pans under piping or equipment that is installed in spaces that have sensitive electronics/electrical equipment such as electrical, IT/AV, telecom, data equipment, elevator machinery rooms, etc. Obtain approval from the Architect prior to installation.

C. Provide drip pans for piping directly above a two hour rated ceiling of an elevator machine room.

D. Provide drip pans, only with written approval obtained prior to installation, installed beneath piping above electrical rooms, telecom rooms, data rooms, servers or any other protected area not clearly indicated by drawings.

E. Provide drip pan supports every 4’-0”.

F. Place flood detector in the lowest location in the drip pan. Interlock detector with the HVAC equipment per manufacturer’s recommendations.

G. Wire flood detector to remote alarm, Diversitech Universal Alarm or equivalent. Coordinate location of the remote alarm with building owner prior to installation.

H. Coordinate interlock of “Water Present” alarm and “Cable Fault” alarm with building automation system. Refer to Division 23 Section “Direct Digital Controls for HVAC” for integration with building automation system and low voltage power wiring.

3.08 ACOUSTICAL PENETRATIONS

A. General: There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partitions. All openings around pipes and ducts in the structure surrounding the mechanical equipment and surrounding noise-critical spaces shall be sealed, packed with caulking for the full depth of the penetration, as described herein.. This includes all slab penetrations and penetrations of noise critical walls.

B. Duct Penetrations: Where each duct passes through a wall, floor or ceiling of a noise critical space, there shall be a clear annular space of 1 inch between the duct and structure. After all of the ductwork is installed, the Contractor shall check the clearance, pack the voids full depth with packing material and caulk both ends with non-hardening sealant backed by foam rod or permanently flexible firestop material. Where there is not sufficient access space to pack around all sides of a duct (for example, at the underside of a slab), place a short stub duct in the wall, pack and caulk around it and then attach the inlet and outlet ducts to each end.

C. HVAC Piping:

1. Provide a steel sleeve cast or grouted into the structure. The internal diameter of the sleeve shall be 2 inches larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, verify the specified clearance and correct it, if necessary, to within 1/2 inch. Pack the void full depth with packing material sealed at both ends, 1 inch deep, with non-hardening sealant backed by foam rod.
2. Provide factory fabricated split seal clamp around the pipe filled with closed-cell neoprene sponge insulation, thickness as required to match adjacent insulation, minimum 3/4 inch. Cast or grout the sleeve into the structure. Provide fiberglass insulation if the pipe is subject to temperatures greater than 225 degrees F. Provide Mason Industries Type SWS or approved equal.

3.09 PLENUM INSULATION

A. General: Plenum insulation shall be installed as a single layer encapsulation applied directly on the surface of combustible items within fire-rated plenums where permitted by the local authority having jurisdiction

B. Overlap: Provide a minimum 1” perimeter and longitudinal overlap at all seams and joints. Seal all cut edges with aluminum foil tape. There shall be no exposed fiber.

C. Secure Attachment: Securely attach insulation using stainless steel tie wire or banding at locations and intervals as recommended by the manufacturer. The entire installation shall comply with the manufacturer’s written installation instructions.

D. Approval: Plenum insulation shall not be installed where not allowed by local authority having jurisdiction. Do not install combustible material within fire-rated plenums where the use of plenum insulation is not approved.

END OF SECTION

PART 1 - GENERAL REQUIREMENTS

1.01 SECTION INCLUDES

A. Joining materials.

B. Escutcheons.

C. Nipples.

D. Unions.

E. Dielectric unions.

F. Dielectric waterway fittings.

G. Dielectric flanges and flange kits.

H. Mechanical sleeve seals.

1.02 SUBMITTALS

A. Refer to Division 01 and Division 23 Section “General Mechanical Requirements” for administrative and procedural requirements for submittals.

B. Product Data, including, rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions.

C. Quality Assurance Submittals: Submit welders' certificates specified in Article “Quality Assurance” below.

D. Piping Schedule: Submit a piping schedule that states the material being proposed for each piping system application in the project including manufacturer’s catalog information, pipe materials, sizes, fittings, Type, Grade, Schedule, applicable ASTM standard, and connection method(s).

E. Submit a schedule of dissimilar metal joints and dielectric flanges, flange kits, unions, or waterway fittings. Include proposed product, joint type materials, and connection method to isolate dissimilar metals. Refer to the individual Division 23 piping system specification sections for piping materials and fittings relative to that particular system and additional requirements.

F. Submit certification that fittings and specialties are manufactured in plants located in the United States or certified that they comply with applicable ANSI and ASTM standards.

G. Manufacturer's Installation Instructions: Indicate hanging and support methods and joining procedures.

H. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

I. Shop Drawings: Include detailed fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure.

J. Coordination Drawings: Include piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

K. As-built drawings for each piping system in electronic and PDF format.

L. Refer to the individual piping system specification sections in Division 23 for additional requirements.

1.03 QUALITY ASSURANCE

A. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code (BPVC), Section IX, “Welding, Brazing, and Fusing Qualifications.”

B. Comply with ASME B31.9 - Building Services Piping, most recent edition.

C. Comply with American Welding Society (AWS), Welding Handbook, most recent edition.

D. Soldering and Brazing procedures shall conform to ANSI B9.1 Safety Code for Mechanical Refrigeration.

E. Pipe specialties and fittings shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ASME, and ANSI standards.

F. Refer to the individual piping system specification sections in Division 23 for additional requirements.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

C. Refer to the individual piping system specification sections in Division 23 for additional requirements.

PART 2 - PRODUCTS AND MATERIALS

2.01 PIPE AND FITTINGS

A. Refer to the individual piping system specification sections in Division 23 for specifications on piping and fittings relative to that particular system.

2.02 JOINING MATERIALS

A. Refer to individual Division 23 Piping Sections for special joining materials not listed below.

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

C. Welding Materials: Comply with AWS D10.12 and Section II, Part C, ASME BPVC for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

D. Brazing Filler Metals: Comply with SFA-5.8, Section II, ASME BPVC for brazing filler metal materials appropriate for the materials being joined.

1. AWS A5.8, Classification BAg–5:

   a) Silver (Ag) 44.0 – 46.0 percent.
   b) Zinc (Z) 23.0 – 27.0 percent.
   c) Copper (Cu) 29.0 – 31.0 percent.

2. AWS A5.8, Classification BCuP–5:

   a) Phosphorus (P) 4.8 - 5.2 percent.
   b) Silver (Ag) 14.5 - 15.5 percent.
   c) Copper (Cu) remainder.

E. Soldering Filler Metals: ASTM B32, 95-5 Tin-Antimony and water flushable flux in accordance with ASTM B813.

F. Plastic Pipe Solvent Cement:

1. PVC: ASTM D2564.
2. CPVC: ASTM F493.

G. Gaskets for Flanged Joints: ASME B16.21, full-faced for cast-iron flanges and raised-face for steel flanges. Select material, thickness, and type to suit the service of the piping system in which installed and which conform to their respective

ASME Standard (A21.11, B16.20, or B16.21). Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.03 ESCUTCHEONS

A. Manufacturers:

1. AWI Manufacturing.
2. Keeney Manufacturing Company.
3. Wal-Rich Corp.
4. Jones Stephens Corp.
5. Approved equal.

B. Chrome-plated, stamped-steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter, or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

2.04 NIPPLES

A. Steel: ASTM A733, made of ASTM A53, Schedule 40, black steel; Type S seamless for pipe sizes 2 inch and smaller, Type E electric-resistance welded for pipe sizes 2-1/2 inch and larger.

2.05 UNIONS:

A. Manufacturers:

1. Anvil International.
2. Hart Industries.
3. Mueller Streamline Co.
4. Victaulic Company of America.
5. Watts Regulator Co.
6. Approved equal.

B. Hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

1. Malleable-iron: ASME B16.39, class as specified in section “Hydronic Piping” for the piping system used.
2. Bronze: ASME B16.15, cast bronze body meeting ASTM B62, class as specified in section “Hydronic Piping” for the piping system used.
3. Copper: ASME B16.22 wrought copper body.
    a) For hydronic systems, provide class as specified in section “Hydronic Piping” for the piping system used.
    b) For refrigerant systems, provide pressure rating as required for the refrigerant type used.

2.06 DIELECTRIC UNIONS

A. Manufacturers:

1. Hart Industries.
2. Victaulic Company of America.
3. Watts Regulator Co.
4. Approved equal.

B. Factory-fabricated with cast bronze body meeting ASTM B584 and galvanized or black steel body with plastic dielectric gasket, class 125 for low pressure service and class 250 for high pressure service, and appropriate end connections for the pipe materials in which installed (screwed or soldered) to effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

2.07 DIELECTRIC WATERWAY FITTINGS

A. Manufacturers:

1. Grinnell Mechanical Products.
2. Victaulic Company of America (Sweat and threaded connections only).
3. Approved equal.

A. Electroplated steel, brass, bronze, or nylon encapsulated nipple, with an inert and non-corrosive, thermoplastic lining, and appropriate end connections for the pipe materials in which installed (screwed, soldered, grooved, or flanged) to effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

2.08 DIELECTRIC FLANGES AND FLANGE KITS

A. Manufacturers:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Pipeline Seal & Insulator, Inc.
4. Tampa Rubber & Gasket Co. Inc.
5. Watts Water Technologies.
6. Approved equal.

B. Full-faced gasket with same outside diameter and bolt hole arrangement as the flange. Conform to ANSI B16.5. Pressure rating of 200 psi for low pressure service and 400 psi for high pressure service at a continuous operating temperature of 180F.

C. Steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves.

D. Flanges: Cast bronze meeting ASTM B584, class 125 solder type or cast iron meeting ASTM A536, class 125 threaded type for low pressure service, bronze class 250 solder type or cast iron class 250 threaded type for high pressure service.

2.09 MECHANICAL SLEEVE SEALS

A. Manufacturers:

1. Thunderline/Link Seal.
2. Calpico, Inc.
3. Metraflex Co.
4. Approved equal.

B. Sleeves: Refer to Division 23 Section "Common Work Results for HVAC" for sleeve materials.

C. Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

PART 3 - EXECUTION

3.01 PREPARATION

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

B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.02 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.

C. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

D. Install piping free of sags and bends and with ample space between piping to permit proper insulation applications.

E. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.

F. Install horizontal piping as high as possible allowing for specified slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

G. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

H. Support piping from structure. Do not support piping from ceilings, equipment, ductwork, conduit and other non-structural elements.

I. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4 inch ball valve, and short 3/4 inch threaded nipple and cap.

J. Verify final equipment locations for roughing in.

K. Use fittings for all changes in direction and all branch connections.

L. Remake leaking joints using new materials.

M. Install components with pressure rating equal to or greater than system operating pressure.

N. Piping Protection:

1. Protect piping during construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.
2. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

3.03 PENETRATIONS

A. Mechanical penetrations occur when piping or ductwork penetrate concrete slabs, concrete or masonry walls, or fire / smoke rated floor and wall assemblies. Reference Division 23 Section “Common Work Results for HVAC” for additional penetration requirements.

B. Above Grade Concrete or Masonry Penetrations:

1. Provide sleeves for pipes passing through above grade concrete or masonry walls, concrete floor or roof slabs. Sleeves are not required for core drilled holes in existing masonry walls, concrete floors or roofs.

   a) Provide Schedule 40 galvanized steel pipe for sleeves smaller than 6 inches in diameter.

b) Provide galvanized sheet metal for sleeves 6 inches in diameter and larger, thickness shall be 10 gauge (0.1382 inches).

c) Provide welded galvanized sheet metal for rectangular sleeves with the following minimum metal thickness:

1) For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 18 gauge (0.052 inches).

2) For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 10 gauge (0.1382 inches).

d) Schedule 40 PVC pipe sleeves are acceptable for use in areas without return air plenums.

2. Extend pipe insulation for insulated pipe through floor, wall and roof penetrations, including fire rated walls and floors. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.

3. Seal elevated floor, exterior wall and roof penetrations watertight and weathertight with non-shrink, non-hardening commercial sealant. Pack with mineral wool and seal both ends with minimum of 1/2 inch of sealant.

C. Elevated Floor Penetrations of Waterproof Membrane:

1. Provide cast-iron sleeves, extend top of sleeve minimum 1 inch above finish floor. Size sleeve for minimum 1/2 inch annular space between pipe and sleeve.

2. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.

3. Pack with mineral wool and seal both ends with minimum of 1/2 inch of waterproof sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

4. Secure waterproof membrane flashing between clamping flange and clamping ring. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."

5. Extend bottom of sleeve below floor slab as required and secure underdeck clamp to hold sleeve rigidly in place.

D. Interior Foundation Penetrations:

1. Provide sleeves for horizontal pipe passing through or under foundation. Sleeves shall be cast iron soil pipe two nominal pipe sizes larger than the pipe served.

E. Interior Penetrations of Non-Fire-Rated Walls:

1. Seal annular space between sleeve and pipe or duct, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of 1/2 inch of sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.
2. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.

F. Fire / Smoke Rated Floor and Wall Assemblies:

1. Seal around penetrations of fire rated assemblies to maintain fire resistance rating of fire-rated assemblies. Coordinate fire ratings and locations with the architectural drawings. Install sealants in compliance with the manufacturer's UL listing. Refer to Division 07 Section "Penetration Firestopping" for special sealers and materials.

G. Acoustical Barrier Penetrations:

1. Where a pipe passes through a wall, ceiling or floor slab of a noise critical space, a steel sleeve shall be cast or grouted into the structure. Refer to Section "Common Work Results for HVAC" for noise critical spaces. The internal diameter of the sleeve shall be minimum of 2 inches larger than the external diameter of the pipe. After the piping is installed, the Contractor shall check the clearance and correct it to within 1/2-inch. Contractor shall pack the void full depth with glass/mineral fiber insulation and seal at both ends, 1-inch deep, with sealant backed by foam rod.
2. Penetration of sound isolating ceilings by sprinkler pipes and heads shall be sleeved and sealed and shall have no rigid connections between them.

3.04 PIPE JOINT CONSTRUCTION

B. Threaded Joints:

1. Provide tapered pipe threads for field cut threads. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full inner diameter.
3. Note the internal length of threads in fittings or valve ends and proximity of internal seat or wall to determine how far pipe should be threaded into joint.
4. Align threads at point of assembly.
5. Apply appropriate tape or thread compound to the male pipe threads except where dry seal threading is specified.
6. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded. Tighten joint to leave not more than 3 threads exposed.
7. Damaged Threads: Do not use pipe or pipe fittings with threads which are corroded or damaged.

C. Flanged Joints:

1. Select appropriate gasket material, size, type, and thickness for service application.

2. Install gasket concentrically positioned.
3. Align flanges surfaces parallel.
4. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible.
5. Use suitable lubricants on bolt threads.
6. Tighten bolts gradually and uniformly using torque wrench.

D. Welded Joints:

1. Comply with the requirement in ASME Code B31.9, "Building Services Piping."
2. Damaged Welds: Do not use pipe sections that have cracked or open welds.

E. Brazed and Soldered Joints:

1. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."
2. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
3. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.
4. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
    1. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making joint.
    2. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
5. Copper-to-copper joints shall be made using BCuP-5 brazing filler metal without flux.
6. Dissimilar metals such as copper and brass shall be jointed using an appropriate flux with either BCuP-5 or BAg-5 brazing filler metal. Apply flux sparingly to the clean tube only and in a manner to avoid leaving any excess inside the completed joint.
7. Continuously purge the pipe and fittings during brazing with an inert gas (i.e., dry nitrogen or carbon dioxide) to prevent formation of scale. Maintain purge until the joint is cool to the touch.
8. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.
9. Provide temporary cap or cover on completed joints with open ends to prevent entry of contaminating materials.

B. Mechanical Refrigerant Pipe Joints: Flared compression fittings may be used for refrigerant lines 3/4 inch and smaller.

F. Socket Joints:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. Prepare surfaces to be solvent cemented by wiping with a clean cloth moistened with acetone or methylethyl keytone.
3. CPVC Joints: Solvent cement joints in accordance with ASTM D2846.
4. PVC Joints: Solvent cement joints in accordance to ASTM D2672.

C. Joints for other piping materials are specified within the respective piping system Sections.

3.05 UNIONS

A. Install unions on pipes 2 inch and smaller, adjacent to each valve, at final connections to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

3.06 DIELECTRIC UNIONS

A. Install dielectric unions for piping 2 inch and smaller to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum) for the following conditions:

   1. Copper or brass connected to carbon steel, stainless steel, cast or ductile iron.

B. Install dielectric unions for piping 2 inch and smaller to connect piping materials of dissimilar metals in wet piping systems (water, steam) for the following conditions:

   1. Copper or brass connected to carbon steel, stainless steel, cast or ductile iron.
   2. Install waterway fittings where installation is concealed. Do not install dielectric unions in concealed spaces.

3.07 DIELECTRIC WATERWAY FITTINGS

A. Install dielectric waterway fittings for piping 2 inch and smaller for copper or brass pipe connections to carbon steel equipment connections.

3.08 DIELECTRIC FLANGES AND FLANGE KITS

A. Install dielectric flanges for piping 2-1/2 inch and larger to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum) for the following conditions:

   1. Copper or brass connected to carbon steel, stainless steel, cast or ductile iron.

B. Install dielectric flanges for piping 2-1/2 inch and larger to connect piping materials of dissimilar metals in wet piping systems (water, steam) for the following conditions:

   1. Copper or brass connected to carbon steel, stainless steel, cast or ductile iron.
   2. Install waterway fittings where installation is concealed. Do not install dielectric flanges in concealed spaces.

C. Provide brass nipples between the equipment connection and dielectric flange for screwed connections. Provide an iron flange for the equipment side and a bronze flange for the copper or brass piping side of the joint.

D. Provide a bronze flange for the copper or brass piping connection to a cast iron, ductile iron or steel flange.

E. Provide full face gasket with pressure rating equal to system served.

F. At each bolt provide steel washers, thermoplastic washers, and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves.

3.09 PIPE FIELD QUALITY CONTROL

A. Testing: Refer to individual piping system specification sections.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General construction and requirements.

B. Applications.

C. Single phase electric motors.

D. Three phase electric motors.

E. Electronically Commutated Motors (ECM).

F. Capacitors.

1.02 REFERENCE STANDARDS

A. ABMA STD 9 – Load Ratings and Fatigue Life for Ball Bearings; most recent edition.

B. IEEE 112 – IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; most recent edition.

C. NEMA MG 1 – Motors and Generators; most recent edition.

D. NFPA 70 – National Electrical Code; most recent edition adopted by the Authority Having Jurisdiction, including all applicable amendments and supplements.

1.03 SUBMITTALS

A. Conform with the submittal procedures in Division 01.

B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements. Provide nameplate data and ratings, mounting arrangements, size and location of winding termination lugs, overload relays, conduit entry, grounding lug, and coatings.

C. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.

D. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

E. Operation Data: Include instructions for safe operating procedures.

F. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.04 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.05 DELIVERY STORAGE AND HANDLING.

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.06 WARRANTY

A. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Baldor Electric Company.

B. General Electric.

C. Gould.

D. Marathon.

E. Regal-Beloit Corporation (Century).

F. Westinghouse

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Electrical Service: All motors shall be supplied in accordance with the following voltage and phase unless noted otherwise on the Drawings.

1. Motors 1/2 HP and Smaller: 115 volts, single phase, 60 Hz.
2. Motors 3/4 HP and Larger: Voltage as scheduled, three phase, 60 Hz.

B. Construction:

1. Open drip-proof except where noted otherwise.
2. Design for continuous operation in 104 degrees F environment.

3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
4. Motors with frame sizes 254T and larger: Energy Efficient Type.

C. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.

E. Wiring Terminations:

1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
2. For fractional horsepower motors where connection is made directly, provide flexible conduit connection in end frame. Maximum length of flexible conduit shall be five feet.

2.03 APPLICATIONS

A. Exception: Motors less than 250 Watts, for intermittent service may be the equipment manufacturer’s standard and need not comply with these specifications.

B. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.

C. Single phase motors for fans, pumps, blowers and air compressors: Capacitor start type.

D. Single phase motors for fans less than 1 hp and greater than 1/12 hp: Electronically commutated type.

E. Motors located in exterior locations, air cooled condensers, humidifiers and explosion proof environments: Totally enclosed fan cooled type.

2.04 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.05 SINGLE PHASE POWER - CAPACITOR START MOTORS

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated ball bearings.

G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.06 THREE PHASE POWER - SQUIRREL CAGE MOTORS

A. Starting Torque: Between 1 and 1-1/2 times full load torque.

B. Starting Current: Six times full load current.

C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.

D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.

E. Insulation System: NEMA Class B or better.

F. Drip-proof Enclosure: NEMA Service Factor.

G. All motors controlled by variable frequency controllers shall have a 1.15 Service Factor.

H. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

I. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

J. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Division 26 - Motor Controlling Equipment.

K. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

L. Sound Power Levels: To NEMA MG 1.

M. All totally enclosed motors shall be fan cooled type. Non-ventilated type motors are not acceptable.

N. Motors controlled by variable frequency drives:

1. Rated for voltage peaks and minimum rise times in accordance with NEMA MG1, Part 31.
2. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
3. Inverter-Duty Motors: Class B temperature rise; Class F insulation.
4. Grounding: Provide shaft grounding system equal to AEGIS SGR Bearing Protection Ring, Inpro/Seal Current Diverter Ring (CDR) or approved equal. Install system in accordance with manufacturer's recommendations.
5. Motor Overload Relay: When a single drive is used to supply power to multiple motors, provide a solid state 3-phase adjustable overload relay between the drive and each motor.

a) Relay shall have manual reset.
b) Provide alarm contact with automatic reset overloads.

O. Part Winding Start, Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

P. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

Q. Nominal Efficiency: Motors shall have minimum NEMA premium efficiency at full load and rated voltage when tested in accordance with IEEE 112.

R. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

2.07 ELECTRONICALLY COMMUTATED MOTORS (ECM)

A. Minimum efficiency: 70 percent when rated in accordance with NEMA Standard MG 1 at full load rating conditions.

B. Motor shall be permanently lubricated with heavy-duty ball bearings to match the equipment load and prewired to the specific voltage and phase.

C. Internal motor circuitry shall convert AC power supplied to the equipment to DC power to operate the motor.

D. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal.

2.08 CAPACITORS

A. Furnish capacitors for power factor correction as specified herein on motors furnished under Division 23 that are not connected to variable frequency drives. KVAR size shall be as required to correct motor power factor to 90 percent or better and shall be installed on all motors 1 horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.

B. Features:

1. Individual unit cells.
2. All welded steel housing.
3. Each capacitor internally fused.
4. Non-flammable synthetic liquid impregnated.
5. Craft tissue insulation.
6. Aluminum foil electrodes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install securely on firm foundation.

C. Check line voltage and phase and ensure agreement with nameplate.

D. Install motor overload relays in a common enclosure adjacent to the variable frequency drive

3.02 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

HP	3600 RPM	1800 RPM	1200 RPM	900 RPM
1/6-1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5-150	1.15	1.15	1.15	1.15

3.03 PERFORMANCE SCHEDULE: THREE PHASE - OPEN DRIP-PROOF

HP	RPM(Sync)	NEMA Frame	Minimum Percent Efficiency	Minimum Power Factor
1	1200	145T	80	72
1-1/2	1200	182T	84	73
2	1200	184T	85.5	75
3	1200	213T	86.5	60
5	1200	215T	87.5	65
7-1/2	1200	254T	88.5	73
10	1200	256T	90.2	74
15	1200	284T	90.2	77
20	1200	286T	91	78
25	1200	324T	91.7	74
30	1200	326T	92.4	78
40	1200	364T	93	77
50	1200	365T	93	79
1	1800	143T	82.5	84
1-1/2	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	86.5	86
5	1800	184T	87.5	87
7-1/2	1800	213T	88.5	86
10	1800	215T	89.5	85
15	1800	256T	91	85
20	1800	256T	91	86
25	1800	284T	91.7	85
30	1800	286T	92.4	88
40	1800	324T	93	83
50	1800	326T	93	85
60	1800	364T	93.6	88
75	1800	365T	94.1	88

1-1/2	3600	143T	82.5	85
2	3600	145T	84	87
3	3600	145T	84	85
5	3600	182T	85.5	86
7-1/2	3600	184T	87.5	88
10	3600	213T	88.5	86
15	3600	215T	89.5	89
20	3600	254T	90.2	89
25	3600	256T	91	92
30	3600	284T	91	91
40	3600	286T	91.7	92
50	3600	324T	92.4	89
60	3600	326T	93	91
75	3600	364T	93	88
100	3600	365T	93	88

3.04 PERFORMANCE SCHEDULE: THREE PHASE-ENERGY EFFICIENT, TOTALLY ENCLOSED, FAN COOLED

HP	RPM(Sync)	NEMA Frame	Minimum Percent Efficiency	Minimum Power Factor
1	1200	145T	80	72
1-1/2	1200	182T	85.5	65
2	1200	184T	86.5	68
3	1200	213T	87.5	63
5	1200	215T	87.5	66
7-1/2	1200	254T	89.5	68
10	1200	256T	89.5	75
15	1200	284T	90.2	72
20	1200	286T	90.2	76
25	1200	324T	91.7	71
30	1200	326T	91.7	79
40	1200	364T	93	78
50	1200	365T	93	81
60	1200	404T	93.6	83
1	1800	143T	82.5	84
1-1/2	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	87.5	83
5	1800	184T	87.5	83
7-1/2	1800	213T	89.5	85

10	1800	215T	89.5	84
15	1800	254T	91	86
20	1800	256T	91	85
25	1800	284T	92.4	84
30	1800	286T	92.4	86
40	1800	324T	93	83
50	1800	326T	93	85
60	1800	364T	93.6	87
75	1800	365T	94.1	87

END OF SECTION

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PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. Variable speed drives shall be furnished for those units so indicated on the drawings. All variable speed drives provided under this section shall be by the same manufacturer.

B. Type of variable speed drive specified in this Section include the following:

1. Pulse Width Modulated

1.02 QUALITY ASSURANCE

A. Testing: The variable speed drive, all components and subassemblies shall be factory tested. The variable speed drive shall be tested and cycled under motor load.

B. Reliability: A complete description of supplier's Quality Assurance and Testing program shall be provided.

1. Component Testing: All power semiconductors and integrated circuits shall be 100% tested.
2. Computerized ATE Testing: Computerized Automated Testing Equipment (ATE) testing shall be used to evaluate functional performance of printed circuit boards. Printed circuit boards shall receive a thermal stress test where temperatures are cycled between 0°C and 65°C and receive electrical power-on and power-off cycle tests.
3. Burn In: All VFD's shall be tested/run in the equivalent of a NEMA 1 or NEMA 3R enclosure and burned in at rated ambient (40°C) with a fully loaded motor.

1.03 CODES AND STANDARDS:

A. The VFD shall meet the following standards.

1. Institute of Electrical and Electronic Engineers (IEEE)

   a) Standard 519-2014 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

2. Nationally recognized testing lab such as UL or ETL

   a) UL 508C (Variable frequency drive)
   b) UL 508A (Bypass)

3. NEMA – ICS 7.0, AC Adjustable Speed Drives

1.04 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product Data: Submit manufacturer's technical product data for variable speed drive including dimensions, capacities, component performance data, ratings, features, motor electrical characteristics, over current protection rating, gages and finishes of material, and installation instructions.
2. Shop Drawings: Submit assembly-type shop drawings including unit dimensions, required clearances, control description, construction details, and field connection details.
3. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to variable speed drives. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
4. Maintenance Data: Submit maintenance instructions, including instructions for adjustments, troubleshooting, operation, testing and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals; in accordance with requirements of Division 1 and Division 23 Section “General Mechanical Requirements.”
5. Harmonic Analysis Report: Provide project-specific calculations and manufacturer’s statement of compliance with IEEE 519.

1.05 WARRANTY

A. Provide warranty including on site parts and labor for minimum 36 months from date of shipment.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL:

A. Provide factory assembled and factory tested variable speed drives as indicated, of sizes and capabilities as scheduled, and as specified herein.

2.02 MANUFACTURERS:

A. Subject to compliance with requirements, manufacturers offering variable speed drives which may be incorporated in the work are limited to the following:

1. ABB.
2. Danfoss.
3. Delta Controls
4. Eaton/Cutler-Hammer.
5. Franklin Control Systems.
6. Invertek.

7. Square D, a division of Schneider Electric.
8. Yaskawa Electric America.

2.03 VARIABLE FREQUENCY DRIVES

A. The VFD shall provide the following design features as standard:

1. Input Section: Full wave rectification shall be achieved with input diodes in a conventional bridge configuration and shall be used to supply voltage to the DC bus. Drive shall be provided with dual DC bus chokes or AC line reactors, as required, for a total input impedance of 5% or better.
2. Output Section: The inverter shall use power transistors to provide three phase output power to the motor.
3. Input Displacement Power Factor: The input displacement power factor shall be 0.97 or higher at all operating speeds and loads.
4. Microprocessor Logic: The VFD shall be microprocessor based and utilize digital input for all parameter adjustments. Use of potentiometers for parameter adjustment is not acceptable.
5. Auto Restart: The VFD shall automatically attempt to restart after a malfunction or an interruption of power. The number of attempted restarts shall be customer selectable (0 to 5). If the drive reaches the limit of restarts without successfully restarting and running for a customer selectable length of time (60 to 600 seconds), the restart circuit shall lockout and shall provide contact annunciation. Delay between attempts to restart shall be customer selectable from 3 to 300 seconds.
6. Current Limit: A current limit circuit shall be provided to limit motor current to a preset adjustable maximum level by reducing the drive operating speed or acceleration rate when the limit is reached. Range of adjustment shall be from 50 to 110%.
7. Digital Output Displays and Input Parameter Programming: The VFD shall include a digital display and digital input programming capability on the main logic board. The display shall be programmable for indication of output speed in rpm, frequency, and percent of base speed, motor amps, output motor volts, and output load. The display shall also function as a first fault indicator.
8. Critical Frequency Avoidance (Frequency Jump Points): The VFD shall provide selectable frequency jump points to be used to avoid critical resonance frequencies of the mechanical system.
9. Input Signal Follower: The input signal follower circuit shall have selectable differential inputs and accept an electrical speed command from an external source rated at 4-20 mA or 0-10Vdc. The input follower circuit shall be capable of operating directly or inversely proportional to the listed speed commands.
10. Motor Overload Protection: Electronic motor protection shall be provided which is capable of predicting motor winding temperature based on inputting specific parameters including motor design type (TEFC, ODP, or other) and speed range. The protection shall provide an orderly shutdown

should the motor's thermal capabilities be exceeded. This protection also eliminates the requirement for motor overload relays on single motor applications when a bypass is not used.

11. Open Collector Outputs: The VFD shall include three (3) open collector outputs to indicate drive run, drive fault, and drive ready.
12. Output Signals: The VFD shall include analog output signals for output load, output speed, instantaneous kw and motor voltage. The signals shall be 4-20 ma or 0-10 Vdc @ 1 mA.
13. Stop Mode Functions: The VFD stopping mode functions shall be selectable for coast-to-rest or stopping at programmed deceleration rate.
14. V/Hz Profiles: The VFD shall provide selectable V/Hz profiles.
15. Loss of Control Signal: The VFD shall revert to the last speed on loss of input control signal. Owner shall be able to field select a preset speed for the VFD to run when control signal is lost, if preferred. In either case, an open collector output shall be selected to indicate loss of control signal for remote indication purposes.

B. The VFD supplier shall provide the same design/technology to cover the HP range for all VFD's.

C. Output Ratings: The VFD shall operate within the following ratings:

1. Frequency range: 1-120 Hz
2. Overload rating: 110% for one minute

D. Motor Performance: The VFD shall provide 3% speed regulation.

E. Input Power: The VFD shall operate within (+5%/-10%) of the nominal rated voltage.

F. Set-up Adjustments: Standard setup adjustments shall include:

1. Minimum speed: 0 to 100%
2. Maximum speed: 0 to 100%
3. Linear accel: 0.5 to 600 seconds
4. Linear decel: 0.5 to 600 seconds
5. Maximum output voltage: Adjustable
6. V/Hz: Adjustable with selectable profiles
7. Current limit: 50 to 110%

G. Environmental Ratings: The VFD shall operate within the following parameters without the requirement for derating:

1. Operating temperature: 0°C to 40°C
2. Altitude: Up to 1000m (3300 ft.)
3. Humidity: 95% non-condensing

H. Enclosure: Refer to VFD schedule or drawings for enclosure type. At minimum, the enclosure shall be suitable for environment installed. Finned heatsinks and/or cooling fans shall be provided as necessary for proper heat dissipation.

I. Protective Features: The VFD shall be designed to meet the following specifications and operate within the following parameters:

1. AC Input Overcurrent Protection: The VFD's power circuit shall be isolated internally with respect to ground and provided with a 100,000 AIC interrupting rated input circuit breaker. As an alternate to the circuit breaker, fuses may be used to accomplish the 100,000 A interrupting rating.
2. Logic Common: The power unit's logic common shall be at ground potential.
3. Phase Loss Protection: Phase loss protection shall be provided to prevent single phasing.
4. Power Loss Ride-Through: The VFD shall be capable of continued operation during an intermittent loss of power. Opening of the VFD's input and/or output line switches while operating shall not result in damage to the power circuit components.
5. Short Circuit and Ground Fault Protection: The VFD shall have an instantaneous electronic trip circuit to protect the VFD from output line-to-line and line-to-ground short circuits. The VFD must be capable of withstanding short circuits at nominal rated voltage plus 10%(i.e., 480V rated drive + 10% = 528V short circuit voltage). The VFD shall be capable of providing 110% motor current intermittently. The VFD shall include an instantaneous overcurrent trip and shall not restart after electronic overcurrent trip until reset through the run/stop circuit, or unless the auto restart function has been enabled.
6. Transient and Surge Voltage Protection: Transient and surge voltage protection shall be provided through the use of Metal Oxide Varistors (MOVs). The VFD shall withstand a 6000 volt, 80 joule surge voltage when tested in accordance with UL 1449 with the test circuit adjusted for a 2100 amp peak 8x20 us short circuit discharge current pulse.
7. Rotating Motor Start: The VFD shall be able to start into a motor rotating in either direction and at any speed, and accelerate to set speed without any time delay, tripping or component loss.
8. DV/DT Filters: Dv/dt filters shall be provided per the VFD schedule, or if recommended by the VFD manufacturer to ensure that the VFD is applied correctly and to maintain the manufacturer’s full warranty.

J. Maintainability

1. All control circuit voltages (12VAC, 24VDC, 160VDC and 120VAC) shall be physically and electrically isolated from power circuit voltages (200 to 600VAC, 600VDC) to ensure safety to maintenance personnel.
2. The VFD shall be furnished with an alphanumeric diagnostic display with fault indications to include the following: bus overvoltage, bus

undervoltage, overcurrent, overtemperature, ground fault, and timed overload.

3. VFD shall be capable of starting and operating without a motor connected for ease of service.
4. All setup and operating parameters shall be stored in nonvolatile memory. The static memory module shall be to be removed and installed in replacement logic boards with all setup and operating parameters intact requiring no adjustment of replacement boards.

K. Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be BACnet, Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.
2. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the building management system to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The building management system shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The building management system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.
3. The VFD shall allow the building management system to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the building management system.
4. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control,

chilled water value control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO & AO commands in memory in the event the serial communications connection is lost.

L. Required Optional Features

1. Operator Panel: A door-mounted Softouch Operator Panel shall be included with the following features:

   a) Shall digitally display motor speed, load, amps, and output volts. (and controller setpoint and system pressure when setpoint controller is included).
   b) Shall have indication for drive run, drive ready, drive fault, plus operator function/status indication such as auto speed reference, and auto restart.
   c) Shall provide selection for Hand/Off/Auto control. In Hand mode, the VFD shall be started and stopped from the operator's panel. In the Auto mode, the VFD shall be started and stopped by remote contact closure. In the Off mode, the VFD shall be locked out.
   d) Shall provide selection for Manual/Auto Speed Reference. In the Manual Reference mode, the VFD speed reference shall be set from the operator's panel. In the Auto Reference mode, the VFD speed reference shall be set by the external source instrument signal. Selecting between Manual and Auto speed reference shall have no bearing on the Hand/Off/Auto start/stop selector, or vice versa.
   e) Shall name all parameters in English, not codes or numbers.
   f) Keypad shall include electronic lock-out feature to prevent unauthorized personnel from parameter access.
   g) Shall store from three to six drive faults in a history batch file in the order they occur to simplify trouble-shooting. This file will automatically be updated should new faults occur.

2. Input Overcurrent Protection Device: The operating mechanism shall be designed so that the door can be padlocked in the "OFF" position.
3. Elapsed Time Meter: Meter shall provide indication of how long the drive has been running.
4. Firestat/Freezestat: VFDs for air system fans requiring shutoff from safety devices per sequences of operation shall provide terminals for connecting normally closed remote safety devices. This emergency shutdown shall operate in any mode of operation.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which variable speed drive is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.02 INSTALLATION

A. General: Install systems and materials in accordance with manufacturer's instruction.

B. Maintain minimum clearance of 12 inches on each side and 36 inches in front of the variable speed drive.

C. Install variable speed drive in the vertical position.

D. Provide separate conduits for input and output power cables.

E. Provide separate conduits for control cables and the output cables to the motor.

F. Install power and control cabling in separate conduits.

G. Provide dedicated conduits for power cables to the motors.

H. Load Side Disconnects: Provide a disconnect switch on the load side of the VFD near the motor for ease of service and safety. Disconnect switch shall be lockable in the open position when the VFD is not within sight of the motor. Operating the switch with the VFD running shall not cause any component failure. In dual motor applications, VFD shall be able to operate either motor with the other motor disconnected without requiring jumpers, parameter modifications, or other adjustments. As part of start-up, VFD supplier shall certify all load side disconnects can be opened or closed with drive running at full speed without damage to the drive.

1. When a separate disconnect is provided at the motor, provide auxiliary contact in the disconnect switch that will shut down the variable speed drive when the disconnect switch is turned off.

3.03 START UP

A. All units shall be started up at the jobsite by a factory trained and authorized representative.

3.04 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train

Owner's designated personnel for a minimum of four hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter written by the Contractor stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided. Copies of the startup report shall be attached to the certification letter.

D. Schedule: Schedule training with Owner with at least 14 days' advance notice.

END OF SECTION

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PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes the following:

1. Flexible Expansion loops
2. Expansion loops

1.02 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

1. Product data for each type of pipe expansion joints specified. Submit expansion compensation schedule showing manufacturer's figure number, size, location, connections, material, and displacement for each required expansion joint.
2. Assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components. Detail fabrication of pipe anchors, hangers, special pipe support assemblies, and their attachment to the building structure. Submit calculations of pipe expansion forces at anchor points for structural engineer review.
3. Shop drawings for field-fabricated expansion loops indicating location, dimensions, pipe sizes, calculations for compression or tension required, and location. Detail fabrication of pipe anchors, hangers, special pipe support assemblies, and their attachment to the building structure. Submit calculations of pipe expansion forces at anchor points for structural engineer review.
4. Maintenance data for expansion joints for inclusion in Operating and Maintenance Manuals specified in Division 1 and Division 23 Section "General Mechanical Requirements."

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following codes:

1. ASME B31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
2. ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications" for Qualifications for Welding Processes and Operators.

B. Expansion joints shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

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

1. Flexible Expansion Loop

   a) Flex-Hose Co.,Inc.
   b) Flexicraft Industries
   c) Metraflex Co. Metraloop
   d) Twin City Hose.

2.02 PIPE EXPANSION JOINTS, GENERAL

A. Pipe expansion joints shall provide 200 percent absorption capacity of piping expansion between anchors.

2.03 FLEXIBLE EXPANSION LOOPS

A. Provide prefabricated expansion compensator loops with inlet and outlet elbow fittings and two (2) sections of metal hose and braid joined by long-radius, 180-degree return bend or center section of metal hose and braid, suitable for an operating pressure and temperature of system. End connections shall match rest of piping system and as required for the size specified in Division 23 Section “Hydronic Piping”.

2.04 EXPANSION LOOPS

A. Provide pipe expansion loop constructed of main pipe material. Acceptable methods include use of elbows in a U or Z shape as defined by ASHRAE or ASME; or a detailed stress analysis may be utilized to define areas of expansion.

2.05 ALIGNMENT GUIDES AND ANCHORS

A. Provide alignment guides and anchors as specified in specification Division 23 Section “Hangers & Supports for HVAC Piping & Equipment”.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Install expansion joints and expansion loops where indicated on the drawings and where required for adequate expansion of installed piping system.

C. Anchor piping to ensure proper direction of expansion and contraction.

3.02 EXPANSION JOINTS

A. Align joints to avoid end loading and torsional stress.

3.03 EXPANSION COMPENSATION FOR RISERS AND TERMINALS

A. Install connection between piping mains and risers with at least 5 pipe fittings including tee in main. Install connections between piping risers and terminal heating and cooling units with at least 4 pipe fittings including tee in riser.

3.04 FLEXIBLE EXPANSION LOOPS

A. Install loops at locations indicated on plans. Amount of expansion shall be as indicated on plans. Loop shall be installed horizontally for steam systems. If installed vertically in chilled or hot water systems, drains and manual air vents shall be installed as required in Division 23 Section “Hydronic Piping”. Support loop as required by manufacturer and to prevent binding or sagging per Division 23 Section “Hangers & Supports for HVAC Piping and Equipment”.

3.05 EXPANSION LOOPS

A. Expansion loop locations and dimensions shall be based on routing shown on plans. If routing is modified, coordinate locations with engineer.

B. Fabricate expansion loops to dimensions indicated on plans.

C. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature. After installation remove temporary space holders as required.

D. Provide air vents and drains for piping in vertical runs in accordance with Division 23 Section “Hydronic Piping”. Provide hangers and supports in accordance with Division 23 Section “Hangers & Supports for HVAC Piping and Equipment”. For expansion loops with horizontal and vertical components, support for the horizontal legs shall be designed for full weight of the pipe with maximum load variation of 25%.

E. Provide alignment guides at locations indicated on plans and as required for piping expansion. At a minimum, install alignment guides on both sides of expansion loop, spaced at twice the height of the U or Z loop (height defined as perpendicular distance of piping from primary pipe direction) or as required by the expansion joint manufacturer. Alignment shall be sufficient to allow for proper installation of expansion joints to prevent binding or torsional stress on joint.

F. Provide anchors at locations indicated on plans and as required for piping expansion. At a minimum install anchors on both sides of straight pipe length incorporating expansion loop.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Applications.

1. General duty valves common to most mechanical piping systems.
2. Special purpose valves are specified in individual piping system specifications.

B. General requirements.

C. Globe valves.

D. Ball valves.

E. Butterfly valves.

F. Check valves.

G. Gate valves.

H. Chainwheels.

1.02 ABBREVIATIONS AND ACRONYMS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene diene monomer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. PTFE: Polytetrafluoroethylene.

G. RS: Rising stem.

H. SWP: Steam working pressure.

I. TFE: Tetrafluoroethylene.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.

B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, pressure and temperature classifications, valve design, body material, seating materials, trim material, dimensions, clearances, rough-in details, weights, support requirements, and piping connections.

C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

E. Maintenance Materials: Furnish Owner with one wrench for every five plug valves, in each size of square plug valve head.

1.04 QUALITY ASSURANCE

A. Manufacturer:

1. Obtain valves for each valve type from a single manufacturer.
2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.
3. Subject to compliance requirements, provide products from one of the manufacturers listed in Valve Schedule in Part 3.

B. Valves shall be certified to meet the specified ASTM, ASME, ANSI, and MSS standards in Part 2 Products, and as follows:

1. ASME B31.9 for building services piping.
2. ASME B31.1 for power piping.

C. Welding Materials and Procedures: Conform to ASME BPVC-IX.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
2. Protect valve parts exposed to piped medium against rust and corrosion.
3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
5. Secure check valves in either the closed position or open position.
6. Adjust butterfly valves to closed or partially closed position.

B. Use the following precautions during storage:

1. Maintain valve end protection and protect flanges and specialties from dirt.

a) Provide temporary inlet and outlet caps.
b) Maintain caps in place until installation.

2. Store valves in shipping containers and maintain in place until installation.

a) Store valves indoors in dry environment.
b) Store valves off the ground in watertight enclosures when indoor storage is not an option.

C. Exercise the following precautions for handling:

1. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products from one of the manufacturers listed in the Valve Schedule in Part 3.

2.02 APPLICATIONS

A. Provide the following valves for the applications if not indicated on Drawings:

1. Throttling (Hydronic): Butterfly, Ball, and Globe.
2. Throttling (Steam): Globe.
3. Isolation (Hydronic): Butterfly, Gate, Ball, and Globe.
4. Isolation (Steam): Gate and Ball.
5. Dead-End: Butterfly and Ball.

B. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.

C. Required Valve End Connections for Non-Wafer Types:

1. Steel Pipe:

a) 2 NPS and Smaller: Threaded ends.
b) 2-1/2 NPS and Larger: Grooved or flanged ends.

2. Copper Tube:

a) 2 NPS and Smaller: Threaded or solder-joint valve ends.

1) Exception: Solder ends not acceptable for hot water or steam pipe.

b) 2-1/2 NPS and Larger: Grooved or flanged ends.

3. Steam and Steam Condensate Pipe: Solder and grooved ends not acceptable.

D. Chilled Water Valves:

1. 2 NPS and Smaller:

    a) Minimum Class: 150.
    b) Body: Bronze.
    c) Allowable Valve Types:

        1) Ball: Two piece. Forged brass body is acceptable to bronze body.

            a) Brass components.
            b) Stainless steel components.

        2) Lift check.
        3) Swing check.
        4) Wafer plate-type check.
        5) Gate.
        6) Globe.

2. 2-1/2 NPS and Larger:

    a) Minimum Class: 150.
    b) Body: Cast iron, except as noted below.
    c) Allowable Valve Types:

        1) Ball: 2-1/2 inch to 3 inch: Three piece, bronze, forged brass, carbon steel, or stainless steel body.

            a) Brass components.
            b) Stainless steel components.

        2) Butterfly: Ductile iron body.
        3) Lift check.
        4) Swing check.
        5) Wafer plate-type check.
        6) Gate.
        7) Globe.

E. Heating Hot Water Valves:

1. 2 NPS and Smaller:

    a) Minimum Class: 150.
    b) Body: Bronze.
    c) Allowable Valve Types:

        1) Ball: Two piece. Forged brass body is acceptable to bronze body.

            a) Brass components.
            b) Stainless steel components.

        2) Lift check.
        3) Swing check.
        4) Wafer plate-type check.

5) Gate.
6) Globe.

2. 2-1/2 NPS and Larger:

a) Minimum Class: 150.
b) Body: Cast iron, except as noted below.
c) Allowable Valve Types:

1) Ball: 2-1/2 inch to 3 inch: Three piece, bronze, forged brass, carbon steel, or stainless steel body.

a) Brass components.
b) Stainless steel components.

2) Butterfly: Ductile iron body.
3) Lift check.
4) Swing check.
5) Wafer plate-type check.
6) Gate.
7) Globe.

2.03 GENERAL REQUIREMENTS

A. Mechanically Joined General Duty Valves:

1. Contractor may provide mechanically joined general duty valves as an option in lieu of, in whole of, or in part of, the general duty valve fitting and joining methods for the specific systems indicated in Article "Applications." Reference Division 23 Section "Mechanically Joined Hydronic Piping Systems."
2. Contractor shall not use mechanically joined general duty valves for hydronic piping in lieu of welded, threaded or flanged valves.

B. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.

C. Valve Sizes: Match upstream piping unless otherwise indicated.

D. Valve Stem Design:

1. Rising stem or rising outside screw and yoke stems.
2. Non-rising stem valves may be used on water systems where headroom prevents full extension of rising stems.

E. Valve Actuator Types:

1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
2. Handwheels: Valves other than quarter-turn types.
3. Hand Lever: Quarter-turn valves 6 NPS and smaller, vinyl-covered.

4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the “Valve Installation” Article.

F. Valves in Insulated Piping: Provide stem extensions so valve operator extends a minimum of 1/2 inches outside of the insulation and the following features:

1. Gate Valves: Rising stem.
2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: Extended neck.
4. Memory Stops: Fully adjustable after insulation is installed.

G. Valve-End Connections:

1. Threaded End Valves: ASME B1.20.1.
2. Flanges: ASME B16.1 for cast iron.
3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5 for steel, ASME B16.24 for bronze.
4. Solder Joint Connections: ANSI B16.18.
5. Grooved End Connections: AWWA C606.

H. General ASME Compliance:

1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
2. Power Piping Valves: ASME B31.1.
3. Building Services Piping Valves: ASME B31.9.

I. Bronze Valves:

1. Fabricate from dezincification resistant material.
2. Copper alloys containing more than 15 percent zinc are not permitted.

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

K. Source Limitations: Obtain each valve type from a single manufacturer.

2.04 BRONZE GLOBE VALVES

A. Class 150, 300 psig CWP:

1. Comply with MSS SP-80, Type 2, nonmetallic disc to metal seat.
2. Body: Bronze; ASTM B62, with integral seat and union bonnet.
3. Ends: Threaded or solder joint.
4. Stem and Disc: Bronze stem, PTFE disc.
5. Packing: Asbestos free, brass gland.
6. Operator: Malleable iron handwheel.

2.05 BRONZE BALL VALVES

A. Two Piece, Class 150, bronze trim, for valves 2 inch and smaller:

1. Comply with MSS SP-110.
2. CWP Rating: 600 psi.
3. Body: Bronze, ASTM B584.
4. Trim: Bronze.
5. Ends: Threaded or solder joint.
6. Seats and Seals: PTFE.
7. Stem: Blowout-proof.
8. Ball: Full port, chrome plated brass.
9. Operator: Vinyl-covered steel handle.

B. Two Piece, Class 150, stainless steel trim, for valves 2 inch and smaller:

1. Comply with MSS SP-110.
2. CWP Rating: 600 psi.
3. Body: Bronze, ASTM B584.
4. Trim: Stainless steel.
5. Ends: Threaded or solder joint.
6. Seats and Seals: PTFE.
7. Stem: Blowout-proof, stainless steel..
8. Ball: Full port, ASTM A276 Type 316 stainless steel.
9. Operator: Vinyl-covered steel handle.

C. Three Piece, Class 150, bronze trim, for valves 2-1/2 inch to 3 inch:

1. Comply with MSS SP-110.
2. CWP Rating: 600 psig.
3. Body: Bronze, ASTM B584.
4. Trim: Bronze.
5. Ends: Threaded or solder joint.
6. Seats and Seals: PTFE.
7. Stem: Blowout-proof.
8. Ball: Full port, chrome plated brass.
9. Operator: Vinyl-covered steel handle.

D. Three Piece, Class 150, stainless steel trim, for valves 2-1/2 inch to 3 inch:

1. Comply with MSS SP-110.
2. CWP Rating: 600 psi.
3. Body: Bronze, ASTM B584.
4. Trim: Stainless steel.
5. Ends: Threaded or solder joint.
6. Seats and Seals: PTFE.
7. Stem: Blowout-proof, stainless steel..
8. Ball: Full port, ASTM A276 Type 316 stainless steel.
9. Operator: Vinyl-covered steel handle.

2.06 BRASS BALL VALVES

A. Two Piece, Class 150, brass trim, for valves 2 inch and smaller:

1. Standard: MSS SP-110.
2. CWP Rating: 600 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass, ASTM A283.
5. Trim: Brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Blowout-proof ,brass.
9. Ball: Chrome plated brass.
10. Port: Full.

B. Two Piece, Class 150, stainless trim, for valves 2 inch and smaller:

1. Standard: MSS SP-110.
2. CWP Rating: 600 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass, ASTM A283.
5. Trim: Stainless steel.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Blowout-proof, stainless steel.
9. Ball: ASTM A276 Type 316 stainless steel.
10. Port: Full.

C. Two Piece, Class 150, Brass Trim, for valves 2-1/2 inch to 3 inch:

1. Standard: MSS SP-110.
2. CWP Rating: 600 psig.
3. Body Design: Three piece.
4. Body Material: Forged brass, ASTM A283.
5. Trim: Brass.
6. Ends: Threaded or soldered ends.
7. Seats: PTFE.
8. Stem: Blowout-proof, brass.
9. Ball: Chrome plated brass.
10. Port: Full

D. Two Piece, Class 150, Stainless Steel Trim, for valves 2-1/2 inch to 3 inch:

1. Standard: MSS SP-110.
2. CWP Rating: 600 psig.
3. Body Design: Three piece.
4. Body Material: Forged brass, ASTM A283.
5. Trim: Stainless steel.
6. Ends: Threaded or soldered ends.

7. Seats: PTFE.
8. Stem: Blowout-proof, stainless steel.
9. Ball: ASTM A276 Type 316 stainless steel.
10. Port: Full

2.07 STAINLESS STEEL BALL VALVES

A. Three Piece, Class 150:

1. Comply with MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: Minimum 1,000 psig.
4. Body: Stainless steel, ASTM A351.
5. Trim: Stainless steel.
6. Ends: Threaded.
7. Seats and Seals: PTFE.
8. Stem: Stainless steel, blowout-proof.
9. Ball: Full port, stainless steel, vented.
10. Operator: Vinyl-covered steel handle.

2.08 CARBON STEEL BALL VALVES

A. Three Piece, Class 150:

1. Comply with MSS SP-72.
2. CWP Rating: Minimum 1,000 psig.
3. Construction: Two-piece or three-piece.
4. Body: Carbon steel, ASTM A216/A216M, Type WCB.
5. Trim: Stainless steel.
6. Ends: Threaded.
7. Seats and Seals: PTFE.
8. Stem: Stainless steel, blowout-proof.
9. Ball: Full port, stainless steel, vented.
10. Operator: Vinyl-covered steel handle.

2.09 IRON BUTTERFLY VALVES

A. Lug type: Bi-directional dead-end service without downstream flange.

1. Comply with MSS SP-67, Type I.
2. CWP Rating: 200 psig and 250 psig.
3. Body Material: ASTM A536 ductile iron.
4. Stem: One or two-piece stainless steel.
5. Seat and Seal: EPDM.
6. Disc: Aluminum-bronze, stainless steel, or one-piece Nylon-coated ductile iron.
7. Operator:

a) Size 2-1/2 through 6 inches: Lever operator, 10 position minimum, with locks and stops.
b) Size 8 inch and larger: Gear type with position indicator.

2.010 BRONZE SWING CHECK VALVES

A. Class 150:

1. Comply with MSS SP-80, Type 3.
2. CWP Rating: 300 psig.
3. Design: Horizontal swing, Y-pattern, capable of being refitted and ground while valve remains in the line.
4. Body: Bronze, ASTM B62.
5. Ends: Threaded.
6. Disc: PTFE.

2.011 IRON, WAFER PLATE-TYPE CHECK VALVES

A. Class 250 Dual-Plate (Twin Disc):

1. Comply with API STD 594.
2. 2-1/2 NPS to 12 NPS, CWP Rating: 400 psig.
3. 14 NPS to 24 NPS, CWP Rating: 300 psig.
4. Design: Wafer, non-slam, spring-loaded plates, designed to open and close at approximately 0.5 psi differential.
5. Body: ASTM A126, cast iron.
6. Ends: Flanged.
7. Trim: Stainless steel.
8. Disc: Bronze.
9. Seat: EPDM, or NBR.

2.012 BRONZE GATE VALVES

A. Class 150:

1. Comply with MSS SP-80, Type I.
2. CWP Rating: 300 psig.
3. Body: Bronze, ASTM B61 with integral seat and union-ring bonnet.
4. Trim: Bronze.
5. Ends: Threaded.
6. Stem: Bronze, RS type. NRS type where exceptions apply.
7. Disc: Solid wedge; bronze.
8. Packing: Asbestos free, brass.
9. Operator: Malleable iron handwheel.

2.013 IRON GATE VALVES

A. Class 250:

1. Comply with MSS SP-70, Type I.

2. 2-1/2 NPS to 12 NPS, CWP Rating: 500 psig.
3. 14 NPS to 24 NPS, CWP Rating: 300 psig.
4. Body: Cast iron, ASTM A126 Class B with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Stem: OS&Y, RS type. NRS type where exceptions apply.
8. Disc: Solid wedge.
9. Packing and Gasket: Asbestos free, 2-piece packing gland assembly.
10. Operator: Malleable iron handwheel.

2.014 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Sprocket Rim with Chain Guides: Ductile iron include zinc coating.
3. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Discard all packing materials and verify that valve interior, including threads and flanges are completely clean without signs of damage or degradation that could result in leakage.

B. Verify valve parts to be fully operational in all positions from closed to fully open.

C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.

D. If valve is determined to be defective, replace with new valve.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Locate valves for easy access. Provide access doors and fire rated access doors as required.

C. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.

D. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.

E. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.

F. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

G. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.

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

I. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

J. Valves with soldered end connections:

1. Use solder with a melting point as follows:

a) Below 840 degrees F for gate, globe, and check valves.
b) Below 421 degrees F for ball valves.

K. Install check valves where necessary to maintain direction of flow as follows:

1. Lift Check: Install horizontal style with stem plumb and vertical.
2. Swing Check: Install horizontal maintaining hinge pin level.
3. Orient plate-type into horizontal or vertical position, between flanges.

L. Provide chainwheels on operators for valves 2-1/2 NPS and larger where located 72 inches or more above finished floor in mechanical rooms, terminating 60 NPS above finished floor.

3.03 FIELD QUALITY CONTROL

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

3.04 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

B. Inspect valves for leaks after piping systems have been tested and put into service, but before final adjusting and balancing. Adjust or replace packing, as required, on valves with leaks. Replace valve if leak persists.

3.05 VALVE SCHEDULE

A. Bronze Globe Valves, Class 150:

MANUFACTURER	THREADED	THREADED	SOLDER

	NRS	RS	RS
Apollo	--	122T	--
Crane	--	7TF	1310
Hammond	--	IB413T	IB423
Jenkins	--	106BJ	--
Milwaukee	--	590T	1590T
Nibco	--	T-235-Y	S-235-Y
Powell	150	--	--
Stockham	--	B-22T	--

B. Bronze Ball Valves – 2 inch and smaller, Class 150:

1. Model for chrome plated brass ball indicated. Furnish SS ball if specified in Part 2.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	77C-140	77C-240
Hammond	8301A	8311A
Milwaukee	BA-400	BA-450
Nibco	T-585-70	S-585-70
Watts	LFB6080G2	LFB6081G2

C. Bronze Ball Valves - 2-1/2 inch to 3 inch, Class 150:

1. Model for chrome plated brass ball indicated. Furnish SS ball if specified in Part 2.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	82-100	82-200
Hammond	8604	8614
Milwaukee	BA-300	BA-350
Nibco	T-595-Y	S-595-Y
Watts	LFB6080G2	LFB6081G2

D. Brass Ball Valves – 2 inch and smaller, Class 150:

1. Model for chrome plated brass ball indicated. Furnish SS ball if specified in Part 2.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	77F-100	77F-200
Bray	S51	
Hammond	8901	8911
Kitz Corporation	AKTFLL	CTFLL
Milwaukee	BA-475B	BA-485B
Nexus Valve Inc.	UX-#F-#F	UX-#S-#S
Nibco	T-FP-600A	S-FP-600A
Watts	FBV-3C	FBVS-3C

E. Brass Ball Valves - 2-1/2 inch to 3 inch, Class 150:

1. Model for chrome plated brass ball indicated. Furnish SS ball if specified in Part 2.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Hammond	8901	8911
Kitz Corporation	AKTAFP	--
Milwaukee	BA-475B	BA-485B
Nexus Valve Inc.	UX-#F-#F	UX-#S-#S
Nibco	T-595-Y	S-595-Y

F. Bronze Lift Check Valves, Class 150:

MANUFACTURER	HORIZONTAL	VERTICAL
Crane	27TF	29
Elite Valve		CKVB
Spirax Sarco	LCV1	

G. Bronze Swing Check Valves:

MANUFACTURER	CLASS 125 THREADED	CLASS 125 SOLDER	CLASS 150 THREADED	CLASS 200 THREADED
Apollo	163T	163S	164T	169T
Crane	41TF	--	141TF	36
Hammond	IB940	--	IB946	IB944
Jenkins	4037J	--	4475TJ	4449J
Milwaukee	509-T	1509-T	510-T	508
Nibco	T-413-Y	S-413-Y	T-433-Y	T-453-B
Powell	578	--	--	560Y
Stockham	B-320-T	B-310-T	B322	B-345

H. Iron Flanged End Swing Check Valves:

MANUFACTURER	CLASS 125	CLASS 250
Apollo	910F	920F
Crane	373	39E
Hammond	IR1124	IR322
Jenkins	587J	339RJ
Milwaukee	F2974	F2970
Nibco	F-918-B	F-968-B
Powell	559	--
Stockham	G-931	F-947

I. Iron Wafer Plate-Type Check Valves:

MANUFACTURER	CLASS 125	CLASS 250
Apollo	910WB	--
Center Line	800	--
Crane	DuoChek StyleG	DuoChek Style G
Metraflex	CVOSSXXX	CVOSSXXX
Nibco	W-920-W	W-960-W
Stockham	WG970	--

J. Silent Check Valves (Wafer Style)

MANUFACTURER	CLASS 125	CLASS 150	CLASS 250	CLASS 300
Flomatic	--	888VFD	--	888VFD
Keckley	CW1CI	CW2CS/36	CW1CI	CW2CS36
Metraflex	CVO700-SS	--	CVO700-SS	--
Mueller	101MAP	101MBP	103MAP	103MBP
Titan	--	CV90/91	--	CV90/91
Valmatic	1400A	--	1400A	--

K. Silent Check Valves (Globe Style)

MANUFACTURER	CLASS 125	CLASS 150	CLASS 250	CLASS 300
Flomatic	402	402	402	402
Keckley	CG1CI	CG2CS/36	CG3CI	CG4CS/36
Metraflex	CVO900-SS	--	CVO900-SS	--
Mueller	105MAP	105MBP	107MAP	109MBP
Titan	--	CV50/51	--	CV52
Valmatic	1800	--	1800	--

L. Bronze Gate Valves, Class 150:

MANUFACTURER	THREADED NRS	THREADED RS	SOLDER NRS	SOLDER RS
Apollo	106T	107T	--	--
Crane	437	431	1324	1334
Hammond	IB638	IB629	--	IB648
Jenkins	2310J	47CUJ	--	--
Milwaukee	1141	1151	--	1169
Nibco	T-136	T-134	S-136	S-134
Powell	2712	2714	--	--
Stockham	B-128	B-120	--	B-124

M. Iron Gate Valves, Class 250:

MANUFACTURER	OS&Y RS	NRS
Apollo	621F	620F
Crane	7-1/2E	3E
Hammond	IR-330	--
Jenkins	204J	203J
Milwaukee	F2894A	--
Nibco	F-667-0	F-669
Powell	1797	--
Stockham	F-667	--

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Support and attachment components.

B. Horizontal piping hangers and supports.

C. Saddles and shields.

D. Vertical piping clamps.

E. Pipe alignment guides.

F. Pipe anchors.

G. Anchors and fasteners.

H. Miscellaneous materials.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

1.03 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each type of hanger and support. Include a hanger and support schedule showing manufacturer's figure number, size, location, and features for each hanger and support. Submit style and type to Structural Engineer for approval prior to installation.

B. Product Certificates: Signed by the manufacturer of hangers and supports certifying the products meet the specified requirements.

C. Welder Certificates: Signed by Contractor certifying that welders comply with requirements specified under "Quality Assurance" Article.

D. Maintenance Data: For inclusion in Operating and Maintenance manual specified in Division 01 and Division 23 Section "General Mechanical Requirements."

E. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution. Include dimensions, weights, required clearances, and method of assembly.

   1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.

F. Installer's Qualifications: Include evidence of compliance with specified requirements.

G. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.04 QUALITY ASSURANCE

A. Comply with applicable building code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Installer Qualifications for Field-Welding:

   1. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
   2. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
   3. Qualify welding processes and welding operators in accordance with ASME BPVC Section IX, "Welding and Brazing Qualifications."

D. Flame/Smoke Ratings: Provide hangers and supports with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by UL 723 or ASTM E84 (NFPA 255) method.

E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS AND MATERIALS

1.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Comply with MSS SP-58.
2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of work.
3. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
6. Materials: Products and materials listed in this specification are based on indoor, dry locations. Use corrosion resistant materials suitable for the environment where installed.

a) Indoor Dry Locations: Provide painted carbon steel, galvanized steel or zinc-plated steel. Where supports will be field painted in exposed locations, provide carbon steel.

a. Indoor Damp or Wet Locations: Galvanized steel or type 304 stainless steel.

b) Outdoor Locations: Galvanized steel or Type 304 stainless steel.

c) Dielectrics Barriers: Provide dielectric barriers between metallic supports and metallic piping and associated items of dissimilar type. Acceptable barriers include rubber, or copper-plated coatings where attachments are in direct contact with copper.

d) Zinc-Plated Steel: Electroplated in accordance with ASTM B633.

e) Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

f) Stainless Steel: Type 304 or 316 in accordance with ASTM A240.

B. Metal Channel (Strut) Framing Systems:

1. Manufacturers:

a) Cooper B-Line.

b) Ferguson Enterprises/FNW.

c) PHD Manufacturing.

d) Thomas & Betts Corporation.
e) Unistrut, a brand of Atkore International Inc.
f) Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.

2. Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
3. Comply with MSS SP-58, Type 59, MSS SP-89, and MFMA-4. Welds shall comply with AWS D1.1.
4. Channel Material:

a) Indoor Dry Locations: Provide carbon steel, galvanized steel or zinc-plated steel. Where supports will be field painted in exposed locations, provide carbon steel .
b) Indoor Damp or Wet Locations: Galvanized steel or Type 304 stainless steel.
c) Outdoor Locations: Galvanized steel or Type 304 stainless steel.
d) All nuts, brackets, and clamps shall have the same finish as the channel.

5. Minimum Channel Thickness: Steel sheet, 14 gage, 0.0747 inch.
6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height with factory-punched attachment holes.
7. Provide plastic galvanic isolators for connecting bare copper pipe for use with pre-engineered support strut system where indicated.

C. Hanger Rods:

1. Material:

a) Indoor Dry Locations: Zinc-plated steel.
b) Indoor Damp or Wet Locations or Outdoor Locations: Zinc-plated steel or type 304 stainless steel.

2. Threaded both ends or continuously threaded.
3. Minimum Size: Reference piping specification sections for rod thicknesses.
4. Threaded Rods: Threaded rods are not allowed for floor supports except when the maximum length of the rod is less than 12”. Threaded rod sizes shall be the same size diameter as specified for pipe hanger rods based upon pipe size being supported. Refer to system piping specification sections for rod size requirements.

D. Wire Rope Pipe Hanging Systems:

1. Manufacturers:

a) ASC Engineered Solutions.
b) Gripple.

2. General: Wire rope hanger system shall have a minimum 5 to 1 safety factor based upon the applied working load being supported.

3. Source Limitations: Furnish associated fittings, accessories, and hardware produced by a single manufacturer.
4. Cast-in-place Concrete Insert: Pressed steel body with sintered steel wedge, 302 stainless steel spring and UV stabilized homopolymer polypropylene end cap. Model: Gripple Spider Hanging Kit.
5. Cable Stud: Carbon steel, zinc-coated, designed for attachment to concrete inserts. Model: ASC Engineered Solutions C120.
6. Cable Coupling: Carbon steel, zinc-coated, designed for attachment to threaded rods. Model: ASC Engineered Solutions C130.
7. Cable Eyelet: Carbon steel, zinc-coated, designed to be directly attached to structural supports via anchors or fasteners. Model: ASC Engineered Solutions C150.
8. Cable Toggle: Carbon steel, zinc-coated, with toggle designed for insertion into 1/2 inch hole through steel deck hat channel and provides anchor when pulled in tension. Model: ASC Engineered Solutions C160.
9. Swivel Toggle Insert: Single assembly attached to wire rope cable, manufactured from plated carbon steel toggle, pins, and shackles; swivel insert engineered to be compatible with concrete insert.
10. Wire Rope: High tensile steel wire rope, to ASTM A1023, Class A zinc coating; minimum 7 by 7 cross-sectional thread construction; having a tensile strength of 256,000 psi; No.3 wire size minimum.
11. Adjustable Fastener: Mild steel (type UG2), 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 500 lb. Model: Gripple No. 2, 3 or 4 UniGrip.

2.02 HORIZONTAL PIPING HANGERS AND SUPPORTS

A. Manufacturers:

1. Armacell.
2. ASC Engineered Solutions.
3. Cooper B-Line, Inc.
4. Elite Components.
5. ERICO/Michigan Hanger Co./Caddy
6. Ferguson/FNW.
7. Halfen-DEHA.
8. Hilti.
9. National Pipe Hanger Corporation.
10. PHD Manufacturing.
11. Power-Strut.
12. Unistrut.

B. Single Hangers:

1. Band Hanger: Carbon steel, adjustable band, adjustable swivel.
2. Split Ring: Carbon steel, adjustable swivel, split ring type.

3. Clevis Hanger: Carbon steel, adjustable, clevis type.
4. Roll Support Hanger: Adjustable steel yoke, cast iron roll.

C. Trapeze and Strut-mounted Supports:

1. Two-piece clamp: Designed for use with channel strut, held in place at channel shoulder when clamp attachment nut is tightened.
2. Roll Support: Adjustable cast iron roll attached to metal channel strut framing system with brackets and nuts.

D. Hangers and strut-mounted supports with pre-manufactured polymer inserts:

1. Manufacturers:

a) ASC Engineered Solutions.
b) Holdrite.
c) Klo-Shure.

2. Strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts designed to receive butted insulation internally. Inserts shall support piping independent of insulation to avoid crushing. Installed system shall provide equal thermal and vapor barrier performance as systems with continuous unbroken insulation. Metal shields are not required with clevis hangers of this type.

E. Spring Hangers:

1. Reference Section "Vibration Isolation for HVAC Piping and Equipment" for spring isolation hangers.

F. Wall Supports:

1. Two-hole strap, galvanized steel or copper to suit pipe material. Provide rigid insulation between strap and pipe to maintain continuous insulation and vapor barrier where required.
2. Welded steel bracket reinforced with angle or strut. Support pipe from bracket using horizontal pipe hanger or support appropriate for the pipe type.

G. Floor Supports:

1. Pipe Saddle: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
2. Roller Support: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

H. Pre-Insulated Supports:

1. Manufacturers:

a) Aeroflex USA, Inc.
b) Armacell.

c) ASC Engineered Solutions
d) Buckaroos, Inc.
e) Cooper B-Line, Inc.
f) Pipe Shields, Inc.

2. General Construction and Requirements:

a) Flexible elastomeric insulation with integral high-density pipe support insert shall conform to ASTM C534, Type I.
b) Surface Burning Characteristics: Assembly shall have a flame spread index/smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.
c) Waterproof calcium silicate insulation shall conform to ASTM C795.
d) Rigid phenolic foam insulation shall conform to ASTM C1126, Type III.
e) Insulation inserts shall be surrounded by a 360 degree jacket or shield.

3. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.

2.03 SADDLES AND SHIELDS

A. Pipe Covering Protection Saddles:

1. Manufacturers: Same as hanger and Supports.
2. Meet MSS SP-58 Type 39A or B, 100-psi average compressive strength, with center rib for pipes 12 inches and larger. Saddles shall cover approximately one sixth of the circumference of the pipe and shall be 12 inches long.

B. Insulation Protection Shield:

1. Sheet metal construction, meeting MSS SP-58 Type 40, of 18 gauge for 5-1/2 inches inside dimension and smaller, 16 gauge for 6-1/2 inches to 10-3/4 inches inside dimension, 14 gauge for 11-3/4 inches to 17 inches inside dimension, and 12 gauge for 18 inches to 28 inches inside dimension.
2. Shield shall cover half of the circumference of the pipe and shall be of length indicated by manufacturer for pipe size and thickness of insulation.
3. Lengths for pipes greater than 2 inches: Minimum 8 inch long section at each support.
4. For pipes 2 inch and smaller without pre-insulated supports, provide insulation protection shields installed between hanger and pipe which meets the following minimum length requirements:

Pipe Size (NPS)	Insulation Thickness (inches)	Minimum Shield Length, (in) 5	6	7	8	9	10
		Hanger Spacing, (ft)					
	0.5	5	6	8	-	-	-
	1	3	5	5	-	-	-

≤ 1	1.5	3	5	5	-	-	-
	2	3	3	3	-	-	-
	3	3	3	3	-	-	-
	0.5	8	8	11	11	12	14
	1	5	6	8	9	11	11
≤ 2	1.5	5	6	8	8	9	9
	2	5	5	6	6	8	8
	3	5	5	6	6	6	8

C. 360 Degree Insulation Protection Shield:

1. Shield shall cover all of the circumference of the pipe with two half circumference sections held together with bolts and nuts and shall be of length indicated by manufacturer for pipe size and thickness of insulation.

D. Plastic Saddles and Shields:

1. Manufacturers:

    a) Armacell.
    b) Eaton.
    c) Hydra-Zorb.
    d) PHD Manufacturing.
    e) Zsi Foster.

2. Polymer-based, snap-on or clip-on design, with non-adhesive surface and lip to allow lateral movement of piping without damaging insulation, field-paintable.

2.04 VERTICAL-PIPING SUPPORTS

A. Manufacturers:

1. ASC Engineered Solutions.
2. Cooper B-Line, Inc.
3. Halfen-DEHA.
4. Hilti.
5. ERICO/Michigan Hanger Co.
6. National Pipe Hanger Corporation.
7. PHD Manufacturing.
8. Power-Strut.
9. Unistrut.

B. Components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have factory applied or field-applied finish.
2. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

3. Components as listed below shall be made of 304 stainless steel where installed in corrosive environments and/or where indicated on the drawings.

C. Riser Clamps with pre-manufactured polymer insert:

1. Manufacturers:

a) Hydra-Zorb; Titan Riser Clamp.
b) National Pipe Hanger.
c) Pipe Hangers, Inc.

2. Riser clamp with pre-manufactured polymer inserts designed to withstand vertical loading and receive butted insulation internally. Inserts shall support piping independent of insulation to avoid crushing. Installed system shall provide equal thermal and vapor barrier performance as systems with continuous unbroken insulation.

2.05 PIPE ALIGNMENT GUIDES

A. Factory fabricated, constructed of cast semi-steel or heavy fabricated steel when applied to steel pipe and copper when applied to copper. Guide shall consist of bolted two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

1. Pipe Diameter 8 inches and Smaller: Spider or sleeve type.
2. Pipe Diameter 10 inches and Larger: Roller type.
3. Pipe Diameter 18 to 30 inches: 1 inch U-bolt.

2.06 PIPE ANCHORS

A. Pre-Insulated Anchors: Galvanized steel or stainless steel assembly with high density insulation insert and no metal-to-metal contact.

B. Anchor Clamps: Assembly with multi-piece clamp, constructed of compatible material with piping or with dielectric barrier.

2.07 ANCHORS AND FASTENERS

A. Manufacturers:

1. Hilti, Inc.
2. Illinois Tool Works, Inc.
3. Phillips.
4. Powers Fasteners, Inc.
5. Rawl.
6. Simpson Strong-Tie Company Inc.

B. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

1. Concrete: Use preset concrete inserts or expansion anchors.
2. Solid or Grout-Filled Masonry: Use expansion anchors.
3. Hollow Masonry: Use toggle bolts.
4. Hollow Stud Walls: Use toggle bolts.
5. Steel: Use beam clamps.
6. Sheet Metal: Use sheet metal screws.
7. Wood: Use wood screws.
8. Plastic and lead anchors are not permitted.
9. Hammer-driven anchors and fasteners are permitted only as follows:
    a) Nails are permitted for attachment of nonmetallic boxes to wood frame construction.
    b) Staples are permitted for attachment of nonmetallic-sheathed cable to wood frame construction.

C. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.

1. Comply with MFMA-4.
2. Channel Material: Use galvanized steel.
3. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch minimum base metal thickness.
4. Spot Inserts: Carbon steel with zinc plating or galvanized steel body and base plate, with protective sleeve for anchor rod insert, sized to accommodate anchor rode dimensions.
5. Manufacturers:
    a) Same as manufacturer of metal channel (strut) framing system.
    b) DeWalt “Bang-It” concrete inserts.

D. Post-Installed Concrete and Masonry Expansion Anchors:

1. Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
2. Self-drilling, drilled flush or shell type. Size inserts to suit threaded rods.

E. Beam Clamps: MSS SP-58 C-Type or adjustable, Types 19 through 23, 25 or 27 through 30 based on required load.

1. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
1. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.

F. Vibration Isolation Anchors: Reference Section “Vibration Isolation for HVAC Piping and Equipment” for vibration isolation anchors.

2.08 MISCELLANEOUS MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36.

B. Malleable Iron: ASTM A47

C. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer’s instructions.

B. Provide hangers and supports according to the Pipe Hanger and Support Schedule below.

C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.

D. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.

E. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.

F. Unless specifically indicated or approved by Architect, do not provide support from roof deck.

G. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

H. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.

I. Provide vibration isolators at hangers and supports where specified in Section “Vibration Isolation for HVAC”.

3.03 INSTALLATION OF HANGERS AND SUPPORTS

A. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58 unless indicated otherwise.

B. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

C. Space attachments within maximum piping span length specified in Division 23 piping sections.

D. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

E. Install hangers, supports, clamps and attachments to support piping properly from building structure.

F. Do not attach to ceilings, equipment, ductwork, conduit and other non-structural elements such as floor and roof decking.

G. Hanger and clamps sizing:

1. Cold Piping: Provide pipe hangers sized for the pipe outside diameter plus insulation thickness.
2. Hot Piping: Provide pipe hangers sized for the pipe outside diameter plus insulation thickness.
3. Vertical Piping: Provide clamps sized for the pipe outside diameter and extend clamp through insulation.
4. Refer to Section "HVAC Insulation" for definition of hot and cold piping and required insulation thickness.

H. Where several pipes can be installed in parallel and at the same elevation, Contractor has option to provide metal channel strut framing. Install supports with maximum spacing specified within Division 23 piping sections.

1. Space strut framing at the required distance for the smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.
2. Where strut systems are attached to walls, install anchor bolts per manufacturer's recommendations.

a) Uninsulated Copper Pipe: Install with plastic galvanic isolators
b) Insulated Tube or Pipe: Install with 360° insulation protection shields or pre-engineered thermal hanger-shield inserts as specified in Section "HVAC Insulation".

I. Install building attachments within concrete or to structural steel.

1. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping as specified in Division 23 piping sections.
2. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts.

J. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Provide two nuts on threaded supports to securely fasten the support.

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

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

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.9 Building Services Piping Code is not exceeded.

N. Insulated Piping: Comply with the following installation requirements.

1. Riser Clamps: Attach riser clamp to piping with riser clamps projecting through insulation. Do not use riser clamps to support horizontal, insulated piping. Seal insulation for hot piping and protect vapor barrier for cold piping as specified in Division 23 Section "HVAC Insulation".

    a) Contractor's Option: Provide riser clamps with pre-manufactured polymer insert.

2. Pipe Covering Protection Saddles: Install pipe covering protection saddles where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

    a) If insulation protection shields are used instead of protection saddles on hot piping where vapor barrier is not required, provide high density insulation insert sized for the insulation thickness used as specified in Division 23 Section "HVAC Insulation".

3. Insulation Protection Shield: Install insulation protection shield with high density insulation insert, sized for the insulation thickness used as specified in Division 23 Section "HVAC Insulation". Do not use polymer-based shields for hot piping.

    a) Exception for 2 inch and smaller horizontal piping with cellular glass, flexible elastomeric, or polyisocyanurate insulation: High density insulation insert is not required. Provide insulation protection shield over the insulation with length specified for pipe size and insulation thickness to prevent puncture or other damage.

4. Contractor's Option: Provide pre-engineered thermal hanger inserts for piping insulated with flexible elastomeric insulation at pipe supports for piping 2-1/2 inches and larger.
5. Contractor's Option: Provide strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts.

O. Strut Framing Systems: Channel strut systems can be used at the Contractors option in lieu of individual hangers for horizontal pipes. Arrange for grouping of parallel runs of horizontal piping. Space channel strut systems at the required distance for the smallest pipe supported. Provide channel gauge and hanger rods per the manufacturer's recommendations for the piping supported. Where strut systems are attached to walls, install anchor bolts per manufacturer's recommendations.

1. Uninsulated Copper Pipe: Install with plastic galvanic isolators
2. Insulated Tube or Pipe: Install with 360 degree insulation protection shields or pre-engineered thermal hanger-shield inserts as specified in Division 23 Section "HVAC Insulation".

P. Vertical Piping Risers:

1. Reference Section "Vibration Isolation for HVAC Piping and Equipment" for piping riser supports.

Q. Wire Rope Hanging Systems:

1. Install in accordance with manufacturer's instructions.
2. Supported load shall not exceed manufacturer's recommended load rating.
3. Applications for Pipe Supports:
    a) 3 inch and smaller.
    b) Wire rope hanging system is not allowed for steam or steam condensate piping.
4. Do not support pipe by wrapping the rope around the pipe.
5. Provide appropriate hanger or support compatible with the wire rope hanging system adjustable fastener as specified in the Pipe Hanger and Support Schedule.
6. Install cast-in-place concrete inserts in elevated concrete slabs.
7. Install bream clamps for attachment to structural beams as required.

3.04 INSTALLATION OF PIPE ALIGNMENT GUIDES

A. Install pipe alignment guides on piping that adjoins expansion joints, as required by expansion joint manufacturer, and elsewhere as indicated on plans and specification sections to eliminate binding and torsional stress on piping systems. Install guides per ASME B31.9 unless noted otherwise. Install pipe insulation at guide to not interfere with movement of pipe within the guide.

B. Install guide to accommodate 1/2 the thermal movement at the adjacent expansion joint.

C. Anchor to building substrate.

3.05 INSTALLATION OF ANCHORS

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

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.06 INSTALLATION OF ROOF EQUIPMENT SUPPORTS

A. Attach roof equipment support to the roof structure according to the manufacturer's installation instructions.

B. Provide multiple single rail equipment supports to uniformly support the equipment.

C. Provide rigid backing material (e.g., insulation, wood, etc.) to maintain cant slope.

D. Install supports to maintain continuous insulation on roof.

E. Provide vibration isolators between roof equipment support and equipment according to Division 23 Section "Vibration Isolation for HVAC."

3.07 EQUIPMENT SUPPORT AND ATTACHMENT

A. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.

B. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls.

C. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.

D. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

E. Preset Concrete Inserts and Expansion Anchors: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.

   1. Where concrete slabs form finished ceiling, locate anchors flush with slab surface.

F. Secure fasteners according to manufacturer's recommended torque settings.

G. Remove temporary supports.

H. Fabricate structural steel supports to suspend equipment from structure above or support equipment from floor.

I. Grouting: Place grout under supports for piping and equipment.

3.08 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

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

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

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

3.09 FIELD QUALITY CONTROL

A. Examine support and attachment components for damage and defects.

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

C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

D. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces. Comply with Division 09 Section “Painting.”

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

E. For galvanized surfaces clean welds, bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

F. Correct deficiencies and replace damaged or defective support and attachment components.

3.010 PIPE HANGER AND SUPPORT SCHEDULE

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

B. Provide the following acceptable hangers and supports for each type of piping system. Hangers and supports may be single type or strut-mounted:

C. Single Hangers:

1. All pipe sizes 1-1/2 inch and less:

a) Band hanger.
b) Swivel split ring.
c) Clevis hanger.

2. Cold and Hot pipe sizes 2 inches and greater where pipes are in stationary position: Clevis hanger.
3. Cold and Hot pipe sizes 2 inches and greater for pipes in the following locations: Roll support hanger.

a) Axial movement due to thermal expansion or contraction generates swing angles in excess of 4 degrees.
b) Between anchor locations shown on the drawings.

D. Trapezes and Strut-mounted Supports:

1. Pipes in stationary position: Two-piece clamp, strut clamp or U-bolts.
2. Cold and Hot pipe sizes 2 inches and greater in the following locations: Roll support.

a) Axial movement due to thermal expansion or contraction generates swing angles in excess of 4 degrees.
b) Between anchor locations shown on the drawings.

E. Wall Supports:

1. Pipe sizes 3 inches and less:

a) Two-hole strap mounted to wall.
b) Welded steel bracket with reinforced angle or strut.

2. Pipe sizes 4 inch and greater:

a) U-bolt.
b) Welded steel bracket with reinforced angle or strut.

F. Floor Supports:

1. Pipes in stationary position: Pipe saddle.
2. Cold and Hot pipe sizes 2 inches and greater in the following locations: Roll support.

a) Axial movement due to thermal expansion or contraction is greater than one inch.
b) Between anchor locations shown on the drawings.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Vibration isolation requirements.

B. Vibration-isolated equipment support bases.

C. Vibration isolators.

1.02 COORDINATION

A. Contractor's Responsibility:

1. Verify the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this specification. Any additional equipment needed to meet the intent of this specification, even if not specifically mentioned herein or in the Contract Documents, shall be supplied by the Contractor without claim for additional payment.
2. Performance or waiving of inspection, testing or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly with the Contract Documents. The Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architects to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.
3. Coordinate selection and arrangement of vibration isolation components with the actual equipment to be installed.
4. Coordinate the work with other trades to provide additional framing and materials required for installation.
5. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
6. Sequencing:

    a) Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

B. Manufacturer's Responsibility:

1. Determine vibration isolation types for all equipment and systems in accordance with the local governing code.

2. Calculate the static deflection requirements for all equipment and systems to provide uniform deflection based on distributed operating weight of actual installed equipment.
3. Select the vibration isolation systems to provide static deflection indicated on the Vibration Isolation Schedule and as specified below. Determine the mounting sizes and layout.
4. Guarantee specified isolation system deflection.
5. Select and size vibration isolators to not exceed the recommended loading of the isolators.
6. Provide installation instructions, drawings and field supervision to ensure proper installation and performance.
7. Verify that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators.

1.03 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.

   1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification method for spring element load capacities. Include clearly outlined procedures for installing and adjusting the isolators.

B. Shop Drawings:

   1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators on each piece of isolated equipment. Indicate equipment weights and static deflections.
   2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable. Indicate equipment mounting provisions.
   3. Piping isolators shown and identified on piping layout drawings.
   4. Concrete foundations, supports, and required reinforcing and forms. These appurtenances shall be provided by another trade. This trade shall furnish the shop drawings, including the following:

      a) Concrete reinforcing steel details and templates for all foundations and supports.
      b) Required hanger bolts.
      c) All other appurtenances necessary for proper installation of equipment.

C. Vibration Isolation System Schedule: Include the following for each isolation element:

1. Manufacturer, isolator type, model number, size.
2. Height when uncompressed and static deflection.
3. Spring constant.
4. Spring outside diameter, free operating, and solid heights.
5. Design of supplementary bases.
6. Details of attachment to load-bearing structure or supplementary framing.

D. Post-Installation Inspection Report:

1. Vibration isolation vendor notice of inspection of all vibration isolators.
2. Vibration isolation vendor notice of approval that all vibration isolators have been properly installed and conform to the specification.
3. Itemized list of deficiencies.
4. Vibration Isolation System Schedule.
5. For each isolator containing steel springs, record the following:

    a. Size.
    b. Uncompressed height.
    c. Design static deflection.
    d. Measured static deflection.

1.04 QUALITY ASSURANCE

A. All vibration isolation equipment shall be furnished by one manufacturer unless specifically approved otherwise in writing by the Engineer.

B. All vibration isolation equipment and materials shall be new and manufactured specifically for the purpose intended.

C. Maintain at the project site a copy of each reference document that prescribes execution requirements.

D. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer’s instructions.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Caldyn, California Dynamics Corp.

B. Kinetics Noise Control.

C. Mason Industries, Inc.

D. Vibration Eliminator Co., Inc.

E. Vibration Mounting and Controls.

F. Vibro-Acoustics.

2.02 VIBRATION ISOLATION REQUIREMENTS

A. Construct vibration isolators out of resilient materials resistant to oil, ozone, and oxidant.

B. Select vibration isolators to provide the static deflection as specified in Part 2 “Products” unless otherwise specified for the application listed in Part 3 “Execution.”

C. Where a pipe run connects multiple equipment, select the pipe isolators for the entire run to suit the connected equipment of greatest static deflection.

D. Vibration isolators shall have either known undeflected heights or calibration markings so that the amount of deflection can be verified after adjustment to determine that the load is within the proper range of the device and that the correct degree of vibration isolation is provided according to the design.

E. Vibration isolators, base frames, and inertia bases shall provide uniform deflection and stability under all operating loads.

F. Isolators for fans shall be sized so that thrust restraints (which would act against turning moment caused by static pressure) are not required.

G. Lateral restraining isolators shall have the same static deflection as the vertical isolators for the equipment being isolated.

H. The theoretical vertical natural frequency for each support point based upon load per isolator and isolator stiffness shall not differ from the design objectives for the equipment as a whole by more than plus/minus 10 percent.

I. All elastomeric mountings shall have a Shore hardness of 30 to 60 plus/minus 5 after minimum aging of 20 days or corresponding over-aging, or as specified herein.

J. Elastomeric isolators that will be exposed to temperatures below 32 degrees F shall be fabricated of natural rubber instead of neoprene.

K. Equipment mounted on vibration isolated bases shall have minimum operating clearance of 1 inch between the base and floor or support beneath unless noted otherwise.

L. Vibration Isolator Assemblies with Steel Springs:

1. Housed or caged spring isolators are not acceptable.
2. Assemblies shall use bare springs, color coded or otherwise identify springs to indicate load capacity.
3. Spring diameter shall not be less than 0.8 of the loaded operating height of the spring.
4. The ratio of the horizontal to vertical spring constant shall be between 1 and 2.
5. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.
6. Assembly shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation.
7. Springs shall operate in the linear portion of their load versus deflection curve over a deflection range of not less than 50 percent above the design deflection.

M. Vibration isolators exposed to weather and other corrosive environments shall be protected with factory corrosion resistance.

1. Exterior applications:

   a) Springs: Cadmium-plated and neoprene coated.
   b) Nuts and bolts: Cadmium plated.
   c) Other metal mounting parts: Hot-dip galvanized.

2. Interior applications: Painted.

2.03 VIBRATION ISOLATED EQUIPMENT SUPPORT BASES

A. Pre-Engineered Roof Equipment Support (Type RES):

1. Reference Section “Hangers and Supports for HVAC Piping and Equipment” for specification of non-vibration isolated, pre-engineered roof equipment supports.

B. Concrete Inertia Base (Type CIB):

1. Description: Engineered steel forms into which concrete is poured, with integrated motor slide base, isolator brackets and anchor bolts, welded or tied reinforcing bars running both ways in a single layer. Where anchor bolt locations fall in concrete, reinforcing steel forms shall include drilled members with sleeves welded below the steel to accept bolts. Height saving steel brackets shall be used in all mounting locations.
2. Size: Beam depth equal to 10 percent of the longest span of the base, 6 inches minimum but not more than 12 inches. Size to accommodate incoming pipe suction diffuser or elbow supports.
3. Mass: Minimum of 1.5 times weight of isolated equipment.
4. When the concrete base is "T" shaped, isolators shall be located under the projections as well as under the main body in order to prevent cantilever distortion.
5. The structural perimeter frame, mounting templates, height saving brackets, and spring system shall be provided as an assembly by the vibration control vendor.
6. Type CIB: Mason Industries Type KSL or approved equal.

2.04 VIBRATION ISOLATORS

A. Ribbed Neoprene “Waffle” Pads (Type WP):

1. Assembly: Single ribbed or crossed double ribbed elastomer in-shear pads, in one or more layers separated and bonded to a minimum 1/4 inch thick galvanized steel shim plate as required to provide selected deflection.
2. Thickness: Each layer 5/16 inch thick.
3. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.05 inches.
4. Type WP: Mason Industries Type W, Type WSW, or approved equal.

B. Neoprene and Cotton Duck Pads (Type DP):

1. Assembly: Neoprene and cotton duck construction, 12 Plys per 1/2 inch thickness.

2. Selection: Thickness or multiple pads in series as required to limit maximum loading to 500 psi and static deflection of 0.1 inches.
3. Type DP: Mason Industries Type HL, or approved equal.

C. Steel Spring Neoprene Mounts (Type SPNM):

1. Assembly: Single or multiple free-standing and laterally stable steel springs without a housing.

a) Light capacity base: Molded elastomeric neoprene load plate.
b) Heavy capacity base: Springs welded to the load plate assembly furnished with integral elastomeric pad.
c) Leveling Device: Rigidly connected to equipment or frame.

2. Selection:

a) Minimum static deflection for equipment mounted on grade slabs shall be 1 inch unless specified otherwise.
b) Minimum static deflection for equipment mounted above grade (suspended) slabs shall be 2 inches unless specified otherwise.

3. Type SPNM: Mason Industries Type SLFH or approved equal.

D. Neoprene Bushing (Type NR):

1. Assembly: Neoprene restraint, rubber-in-shear bushings for lightweight, suspended equipment supported from structure with all-thread rod and angle iron or Unistrut.
2. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.15 inches.
3. Type NR: Mason Industries Type HMIB or approved equal.

E. Double Deflection Neoprene Hangers ((Type DDNH)

1. Assembly: Steel hanger box containing a laterally stable, double deflecting, neoprene isolator . Neoprene isolator shall prevent contact between the lower hanger rod and hanger box and short-circuiting the isolating function.

a) Housing: Bottom opening sized to allow hanger rod to swing through a 30 degree arc.

2. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.4 inches.
3. Type DDNH: Mason Industries Type HD or approved equal.

F. Spring and Neoprene Hanger (Type SPNH)

1. Assembly: Steel hanger box containing a laterally stable, double deflecting, neoprene isolator in series with a steel spring.

    a) Housing: Include a neoprene bushing to prevent contact between the lower hanger rod and hanger box and short-circuiting the isolating function. Bottom opening sized to allow hanger rod to swing through a 30 degree arc.

2. Selection:

    a) Neoprene isolator: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.4 inches unless specified otherwise.
    b) Spring isolator: Minimum static deflection of 2 inches unless specified otherwise.

3. Type SPNH: Mason Industries Type 30N or approved equal.

G. Neoprene Mounting Sleeves, Grommets, and Bushings: Designed to prevent steel-to-steel contact within vibration isolators.

H. Flexible Connectors:

1. Pipe: Refer to Section "Hydronic Piping Specialties."
2. Duct: Refer to Section "Air Duct Accessories."

I. Pipe Riser Anchor (Type PRA)

1. Assembly: Telescoping arrangement of two sizes of steel tubing separated by minimum 1/2 inch thick, 60 durometer neoprene. Anchor shall include tapped hole on the top plate for bolt attachment to riser clamp. Anchor shall allow for all-directional movement.
2. Selection: Static deflection of 0.1 inches, maximum allowable load on the isolation material shall not exceed 500 psi.
3. Type PRA: Mason Industries Type ADAH or approved equal.

J. Pipe Riser Guide (Type PRG):

1. Assembly: Telescoping arrangement of two sizes of steel tubing separated by minimum 1/2 inch thick, 60 durometer neoprene with set screw to prevent lateral movement. Guide shall include tapped hole on the top plate for bolt attachment to riser clamp.
2. Type PRG: Mason Industries Type VSGH or approved equal.

K. Riser Suspension Anchor (Type PRSA):

1. Assembly: Steel hanger box containing laterally stable steel spring with integral deflection scale, adjustment plate, and nut. Housing shall include tapped hole at the top for hanger rod attachment.
2. Selection: Minimum static deflection of 4 inches.
3. Type PRSA: Mason Industries Type HES or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that mounting surfaces are ready to receive vibration isolation and associated attachments.

3.02 INSTALLATION - GENERAL

A. Install in accordance with manufacturer's instructions.

B. External spring isolators are not required if unit is provided with internal spring isolation. If external spring isolators are provided, internal spring isolation shall not be approved.

C. Mount or suspend all equipment, piping, ductwork, etc. from approved foundations and supports as specified herein or as shown on the drawings.

D. Secure fasteners according to manufacturer's recommended torque settings.

E. Support piping, ductwork, conduit, and mechanical equipment from the building structure. Do not support from other equipment, piping, or ductwork.

F. Install isolators to prevent short-circuiting of the isolation.

G. All wiring connections to mechanical equipment on isolators shall have a minimum 18 inch long flexible conduit in a "U" shaped loop. Coordinate with Division 26.

H. Flexible Connectors: Install flexible connectors sized to match equipment connections and to provide sufficient slack for vibration isolation as required.

I. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping. Block-up equipment with temporary shims to final operating height. When the system is assembled full load is applied, adjust the isolators shall be adjusted to allow shim removal.

J. Refer to Division 23 Section “Common Work Results for HVAC” for noise critical spaces.

3.03 INSTALLATION OF VIBRATION ISOLATED EQUIPMENT SUPPORT BASES

A. All floor-mounted equipment shall be erected on housekeeping pads. Refer to Section “Common Work Results for HVAC” for concrete housekeeping pad requirements.

B. Maintain minimum 4 inches clearance between isolated equipment and the walls, ceiling, floors, columns, and any other equipment not installed on vibration isolators.

C. Set steel bases for one inch clearance between housekeeping pad and base.

D. Set concrete inertia bases for 2 inches clearance between housekeeping pad and base.

E. Adjust equipment to be level.

F. Verify no material is left to short-circuit the isolator.

3.04 INSTALLATION OF VIBRATION ISOLATORS

A. Neoprene Mounting Sleeves, Grommets, and Bushings: Install on vibration isolators to prevent any metal to metal contact.

B. Spring Isolators:

1. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
2. Install springs so that the ends of springs remain parallel and all springs are installed with adjustment bolts.
3. Locate isolation hangers at the top of hanger rods.
4. Type SPNM: Unless otherwise specified, isolators need not be bolted to the floor for indoor installations.
5. Type SPNH and DDNH: Install the hanger box to allow it to rotate a full 360 degrees without encountering any obstruction.

C. Isolating Pipe Anchors:

1. Weld anchor base to support steel or bolt base plate to structure. Weld or bolt pipe clamp or bracket to anchor.

3.05 EQUIPMENT ISOLATION

A. Air Handling Units:

1. Units that are furnished with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, do not require an additional structural frame installed beneath the unit.
2. Support condensate drain pipes from the isolated air handling unit frame.
3. Slab-on-Grade: Housekeeping pad base, Type SPNM isolation with 1 inch static deflection.
4. Suspended Slab: Housekeeping pad base, Type SPNM isolation with 2 inch static deflection.

B. Water Source Heat Pumps, Fan Coil Units, and Computer Room Units:

1. Floor-mounted (Concealed): Housekeeping pad base, Type SPNM isolation with 0.75 inch static deflection.
2. Floor-mounted (Exposed): Type WP isolation continuous along support.
3. Suspended: Flexible duct connectors with Type SPNH with 1 inch static deflection.

C. VAV Terminal Units:

1. All other Types: Flexible duct connectors.

D. Centrifugal or Scroll Chillers:

1. Slab-on-Grade: Housekeeping pad base, Type WP isolation continuous along support.

E. Screw Chillers:

1. Slab-on-Grade: Housekeeping pad base, Type WP isolation continuous along support.

F. Boilers:

1. All Applications: Housekeeping pad base, Type WP isolation continuous along support.

G. Inline Pumps:

1. Pump supported independent of piping:

a) Provide flexible connectors on each side of pump. The vertical load shall be carried by the supports, not by the flexible couplings.
b) Suspended: Type SPNH isolation with 2 inch static deflection.

H. Base-mounted Pumps:

1. Slab-on-Grade:

a) Less than 50 hp: Housekeeping pad.

I. Fans

1. Suspended:

a) Fans 1 hp and less: Type NR isolation with 0.15 inch static deflection.
b) Fans greater than 1 hp: Type SPNH isolation with 2 inch static deflection.

2. Roof-mounted:

a) Curb mounting: Type RES curb base, with closed cell sponge gasket for sealing, continuous along support sealed to curb top rail.

J. Pneumatic Air Compressors and Vacuum Pumps

1. Slab-on-Grade up to 10 hp: Housekeeping pad, Type SPNM isolation with static deflection of 0.75 inches.
2. Slab-on-Grade 10 hp and greater: Housekeeping pad under Type CIB base, Type SPNM isolation with 1 inch static deflection.
3. Suspended Slab: Housekeeping pad under Type CIB base, Type SPNM isolation with 2 inch static deflection.

K. Unit Heaters: Type SPNH isolation with 2 inch static deflection.

L. All other equipment not specifically identified in this specification that contains rotating or vibrating elements and any associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or RNM neoprene isolators as appropriate.

3.06 PIPING ISOLATION

A. Provide isolation supports on the following HVAC pipe:

1. Piping within 50 feet of the following connected rotating equipment. Provide Type SPNH or SPNM isolators. The first three isolators both upstream and downstream of equipment shall have a static deflection equal to that of the equipment isolators, up to a maximum of 2 inches. The static deflection of the remaining pipe isolators shall be 0.75 inch.

   a) Chillers.
   b) Pumps with motors greater than 5 hp.
   c) Base mounted air handling units with fan motors greater than 5 hp and no internal isolation.

2. Piping within 20 feet of the following suspended equipment: Provide Type SPNH isolators. The first isolator both upstream and downstream of equipment on springs shall have a static deflection equal to that of the equipment isolators, up to a maximum of 2 inches. The static deflection of the remaining pipe isolators shall be 0.75 inch.

   a) Pipes connected without flexible connectors to suspended equipment that is installed with spring vibration isolators.
   b) Pipes connected without flexible connectors to suspended in-line pumps.

3. Steam Pipe Connected to PRV Stations
4. Piping installed below or adjacent to noise sensitive areas:

   a) Refer to Section "Common Work Results for HVAC" for definition of noise sensitive areas.
   b) Isolate all piping larger than 2 inch from the structure with spring and rubber type SPNH or SPNM isolators with 0.75 inch deflection.
   c) Isolate all 2 inch and smaller HVAC piping from the structure with sponge neoprene, felt, or glass/mineral fiber sleeves between the pipe and pipe clamp or with Type WP pads between the clamp and the structure. The sleeve shall be not less than 1/8-inch in thickness when compressed.

B. Provide flexible connectors for piping system connections on equipment side of shutoff valves for all pumps, mechanical equipment supported or suspended by spring isolators, and where indicated on Drawings.

C. Provide resilient diagonal mountings or other approved devices as required to limit piping motion due to equipment startup or shut down to a maximum of 1/8 inch.

D. Where supplementary steel is required to support pipes, size the supplementary steel so that maximum deflection between supports does not exceed 0.08 inches. Isolate the supplementary steel from building structure using the same isolator required for the pipe. Rigidly suspend or support the pipe from the supplementary steel.

E. Provide pre-compressed hanger rod isolators for all pipes greater than 12 inch diameter and all supplementary steel supports used for the large pipe. Factory set the pre-compression at 75 percent of rated deflection.

F. Where isolated pipe 8 inch and larger is supported from exposed steel beams, use welded channel beam attachments located directly under the web of the beam. For piping 6 inch and smaller, beam clamps may be used in lieu of welding, subject to approval of beam clamp selection.

G. Vertical Piping Riser Supports:

1. Do not exceed pipe stresses allowed by ASME B31.9.
2. Provide multiple supports along riser so that each isolator support is loaded for 50 psi maximum. Provide tapped hole in top of support for rigid attachment of pipe riser clamp to support.
3. Riser Supports: Pipe clamp on top of Type DP or Type WP.
4. Risers Subject to Thermal Expansion:

   a) Support vertical pipe risers subjected to thermal expansion and/or contraction with spring isolators, anchors, and guides designed to ensure loading within design limits at support points. Perform design calculations for sizing the riser supports incorporating the initial load, initial deflection, change in deflection, final load and change in load at support locations. Design calculations must include anchor loads when installed, cold filled and at operating temperature and pipe stress at end connections and branch locations. Design system for an initial spring deflection of at least 4 times the thermal movement. Design must be stamped and signed by a licensed professional engineer.
   b) Spring Isolators: Type SPNH, DDNH, or PRSA.
   c) Anchors: Type PRA.
   d) Guides: Type PRG.
   e) Reference Section "Expansion Fittings and Loops for HVAC Piping" for expansion joints.

3.07 DUCT ISOLATION

A. Connect ducts to equipment, fans, fan casings, and fan plenums with flexible connectors.

B. Support grease exhaust ducts with Type SPNH and/or SPNM isolators as appropriate. Install neoprene riser guides if lateral restraint is required in shafts.

3.08 FIELD QUALITY CONTROL

A. Arrange for inspection of all isolation and noise control equipment by the vibration isolation vendor and submit post-installation inspection report.

B. The installation of all vibration isolation systems shall be under the supervision of the manufacturer's representative.

C. Guarantee: If, in the actual installation, any equipment fails to meet the vibration control requirements specified herein, that equipment shall be corrected or replaced without claim for additional payment, inclusive of all labor and material costs. Such corrective measures shall be done within a time schedule specified by the Owner.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Adhesive-backed duct markers.

D. Stencils.

E. Pipe markers.

F. Ceiling tacks.

G. Engraved plastic-laminate signs.

1.02 SUBMITTALS

A. Custom Signage: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

B. Valve Tag Schedule: Submit 8-1/2 x 11 inch typewritten valve schedule. Furnish one extra copy for each maintenance manual. Include the following information in the schedule:

1. Valve tag number.
2. Piping system and system abbreviation as shown on tag.
3. Location of valve (room or space).
4. Variations for identification (if any).
5. Function. Specially mark valves which are intended for emergency shut-off and similar special uses in margin of schedule.
6. Valve manufacturer's name and model number.

C. Product Data: Submit manufacturer's technical product data for each product required.

D. Manufacturer’s Installation Instructions: Indicate special procedures and installation for each product required.

1.03 SPARE PARTS

A. Furnish minimum of 5 percent extra stock of each mechanical identification material required for each system that uses the identification material.

B. Furnish not less than 3 additional numbered valve tags for each piping system.

C. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock along with stenciling paints and applicators.

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCEPTABLE MANUFACTURERS

A. Advanced Graphic Engraving, LLC.

B. Brady Corporation.

C. Brimar Industries, Inc.

D. Craftmark.

E. Industrial Safety Supply Co., Inc.

F. Kolbi Pipe Marker Co.

G. MIFAB, Inc.

H. Seton Identification Products, a Tricor Direct Company..

2.02 IDENTIFICATION APPLICATIONS AND REQUIREMENTS

A. General:

1. Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than a single type is specified for application, selection is the installer's option, but provide single selection for each product category.

2. Lettering: Coordinate names, abbreviations, and other designations used in mechanical identification work with the corresponding designations shown on the drawings, scheduled, and specified. If not otherwise indicated, provide numbering, lettering, and wording as recommended by the manufacturer or as required for proper identification, operation, and maintenance of mechanical systems and equipment.
3. Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (e.g., Boiler No. 3, Air Supply No. 1H, etc.).

B. Air Handling Units: Nameplates, stencils, or engraved plastic laminate signs.

C. Air Terminal Units: Tags, stencils, or engraved plastic laminate signs.

D. Automatic Controls: Tags, use the same naming convention coordinated with the building automation system.

E. Control Panels: Nameplates.

F. Dampers: Ceiling tacks where located above lay-in ceiling. Do not use ceiling tacks in a gyp ceiling.

G. Ductwork: Adhesive-backed duct markers. Stencils are only acceptable for concealed ductwork, exterior ductwork, or in mechanical rooms.

H. Fans: Nameplates, stencils, or engraved plastic laminate signs.

I. Instrumentation: Tags.

J. Major Control Components including Variable Frequency Drives: Nameplates or engraved plastic laminate signs.

K. Piping: Pipe Markers.

L. Pumps: Nameplates or engraved plastic laminate signs.

M. Relays: Tags.

N. Small-sized Equipment: Tags.

O. Tanks: Nameplates or engraved plastic laminate signs.

P. Thermostats: Nameplates.

Q. Valves: Tags. Ceiling tacks are acceptable where located above a lay-in ceiling. Do not use ceiling tacks in a gyp ceiling.

R. Water Treatment Devices: Nameplates or engraved plastic laminate signs.

S. General Signs: Engraved plastic laminate signs.

2.03 NAMEPLATES

A. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and mark number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

B. Size: 2-1/2 inch x 4 inch for control panels and components, 4-1/2 inch x 6 inch for equipment.

C. Letter Color: White.

D. Letter Height: 1/4 inch.

E. Background Color:

1. Cooling equipment: Green.
2. Heating equipment: Yellow.
3. Combination cooling and heating equipment: Yellow/Green.
4. Energy reclamation equipment: Brown.
5. Hazardous equipment: Colors and designs recommended by ASME.
6. Equipment and components that do not meet any of the above criteria: Blue.

F. Plastic: Conform to ASTM D709.

2.04 TAGS

A. Plastic Laminate Tags: Laminated three-layer plastic, minimum 3/32 inch thick, with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter and 5/32 inch hole for fastener.

B. Solid Plastic Tags: Solid plastic, minimum 3/32 inch thick, with printed black letters on white color. Tag size minimum 1-1/2 inch diameter and 5/32 inch hole for fastener.

C. Metal Tags: Provide 19-gauge polished brass with stamped letters. Tag size minimum 1-1/2 inch diameter with smooth edges and 5/32 inch hole for fastener. Fill tag engraving with black enamel paint.

D. Accident Prevention Tags: Pre-printed or partially pre-printed, of plasticized card stock with matte finish suitable for writing, minimum 3-1/4 inch x 5-5/8 inch size, with brass grommet in hole for fastener. Order with appropriate pre-printed wording (e.g., DANGER, CAUTION, DO NOT OPERATE, etc.).

E. Tag Fasteners: Solid brass chain (wire link or beaded type), or solid brass S-hooks of the size required for proper attachment of tags to valves, manufactured specifically for that purpose.

F. Valve Tag Chart: Typewritten letter size list in anodized aluminum or finished hardwood frame, covered with SSB-grade sheet glass. Provide frame and mounting screws for removable mounting.

G. Letter Height:

1. System Abbreviation: Minimum 1/4 inch.
2. Valve Number: Minimum 1/2 inch.

2.05 ADHESIVE-BACKED DUCT MARKERS

A. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.

B. Style: Individual label.

C. Nomenclature: Include air handling unit identification number, duct size, service, and arrows indicating direction of flow.

D. Specialty Exhaust: Identify the specialty using the system terminology (e.g., Grease, Dishwasher, Dryer, Fume Hood, etc.).

E. Color: Yellow background with black lettering or blue background with white lettering.

1. Hazardous Exhaust: Use colors and designs recommended by ASME A13.1.

2.06 STENCILS

A. Stencils: With clean cut symbols and letters of following size, complying with ASME A13.1:

1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
6. Ductwork and Equipment: 2-1/2 inch high letters.
7. Access Doors: 3/4 inch high letters.
8. Operational Instructions: 3/4 inch high letters.
9. Provide arrows indicating direction of flow.

B. Stencil Paint: Oil based, alkyd enamel, either brushing grade or pressurized spray-can form and grade, black color, except for piping. For piping systems use colors conforming to ASME A13.1.

2.07 PIPE MARKERS

A. Semi-rigid Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

B. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings, minimum 3 mil thick.

1. Width: 1-1/2 inch for pipes less than 6 inches (including insulation), 2-1/2 inch for pipes 6 inches and larger (including insulation).

C. Pipe Marker with Insulation: 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F or greater. Insulation shall extend 2 inches beyond each end of plastic pipe marker.

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

1. Detection: Provide multi-ply tape consisting of solid aluminum foil core between two layers of plastic ribbon tape.

E. Nomenclature: Manufacturer's standard pre-printed nomenclature which best describes piping system. Differentiate between supply and return. In the case of a variance, provide nomenclature as selected by the Engineer.

F. Arrows: Provide pipe markers with integral arrows indicating direction of flow or as a separate unit of plastic.

G. Color:

1. Conform to ASME A13.1.
2. Heating, Cooling, and Boiler Feedwater: Green with white letters.
3. Toxic and Corrosive Fluids: Orange with black letters.
4. Compressed Air: Blue with white letters.

H. Letter Height: Minimum 1/2 inch for pipes up to 3 inch, minimum 1 inch for larger pipes.

2.08 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

B. Color:

1. HVAC Equipment: Yellow.
2. Fire Dampers and Smoke Dampers: Red.
3. Heating/Cooling Valves: Blue.

2.09 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Engraving stock melamine plastic laminate, engraved with manufacturer’s standard letter style, black with white core letter color except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16 inch thick for units up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger units.

C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

D. Nomenclature: When used to identify equipment, match terminology on schedules, including the following:

1. Name and mark number.
2. Equipment service.
3. Design capacity.

E. Access Panel Markers: Laminated three-layer plastic, minimum 1/16 inch thick and 1/8 inch hole for fastener, with abbreviations and numbers corresponding to concealed valve.

PART 3 - EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.02 GENERAL INSTALLATION

A. Coordination: 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. Install products in accordance with manufacturer’s instructions.

C. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

D. Install tags on piping 3/4 inch diameter and smaller.

E. Install in clear view and align with axis of piping.

F. Apply stencil painting in accordance with Division 09.

G. Identify service, flow direction, and pressure.

3.03 PIPING IDENTIFICATION

A. General: Install identification on the most obviously visible portion of the pipe from the point of access.

B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

C. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe during back-filling/top-soiling of each underground piping system, Where multiple pipes are buried in common trench and do not exceed overall width of 16 inches, install single pipe marker. For tile fields and similar artificial field installations, mark only edge pipe lines of field.

D. Pipes less than 6 inches diameter (including insulation):, Provide full-band pipe markers with 360 degree coverage.

E. Pipes 6 inches diameter and larger (including insulation): Provide either full-band or strip-type pipe markers.

F. Location: Install piping identification where piping is exposed to view, concealed by a removable ceiling system, located in accessible maintenance spaces (shafts, tunnels, plenums, etc.) and exterior non-concealed locations as follows:

1. Within 5 feet of each valve, tee, and control device.
2. Within 5 feet of each branch, excluding branches less than 25 feet in length to fixtures or terminal heating and cooling units.
3. Within 5 feet of each side of a penetration of a wall, floor, ceiling, structure, or enclosure.
4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Within 5 feet of equipment outlets and other points of origination and termination.

6. Spaced intermediately at a maximum spacing of 50 feet along each riser and run. Reduce spacing to 25 feet in congested areas where there are more than two piping systems or pieces of equipment.

3.04 VALVE IDENTIFICATION

A. Provide a tag on each valve, cock, and control device. Exclude check valves, valves within factory-fabricated equipment, HVAC terminal devices, and similar rough-in connections of end-use fixtures and units.

B. Mount valve tag chart and schedule frame in mechanical room, or where indicated on plans. If not indicated, mount where directed by Engineer. Where more than one mechanical room is included on the project, mount framed copies of valve tag chart and schedule in each mechanical room.

3.05 DUCTWORK IDENTIFICATION

A. Install identification on the most obviously visible portion of the duct from the point of access.

B. Location: Install ductwork identification where ductwork is exposed to view, concealed by a removable ceiling system, located in accessible maintenance spaces (shafts, tunnels, plenums, etc), and exterior non-concealed locations as follows:

1. Within 5 feet of each control damper or balancing damper, excluding balancing dampers installed in duct take-offs to individual grilles, registers, or diffusers that are less than 25 feet in lengths and installed in the same space as the air device.
2. Within 5 feet of each branch duct, excluding branch ducts that are less than 25 feet in length and located in the same space as the main duct.
3. Within 5 feet of each side of a penetration of a wall, floor, ceiling, structure, or enclosure.
4. Spaced intermittently at a maximum spacing of 50 feet along each duct run. Reduce spacing to 25 feet in congested areas when there are more than two types of duct systems or pieces of equipment.
5. Within 5 feet of equipment outlets and other points of origin or termination.
6. Install marker on the most obviously visible portion of the duct from point of access.

3.06 ACCESS DOOR IDENTIFICATION

A. Provide identification on each access door, indicating purpose of access, maintenance and operating instructions, and appropriate safety and procedural information.

B. Where access doors are concealed above a removeable ceiling system or similar concealment, tags may be used in lieu of specified identification.

3.07 CEILING TACK INSTALLATION

A. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

3.08 EQUIPMENT IDENTIFICATION

A. Install nameplates and engraved plastic laminate signs for identification of equipment. Provide additional signs and lettering as follows:

1. To distinguish between multiple units in close proximity.
2. To inform operator of operational requirements.
3. To indicate safety and emergency precautions.
4. To warn of hazards and improper operations.

B. Adjust lettering size based on viewing distance from normal location of identification:

1. Less than 2 feet: Minimum 1/4 inch.
2. Up to 6 feet: Minimum 1/2 inch.
3. Greater than 6 feet: Proportionally increase letter size based on recommendations above.
4. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
5. Stencils may be used in lieu of nameplates when lettering greater than 1 inch is needed for proper identification because of distance from normal location of required identification.

C. Where equipment to be identified is concealed above acoustical ceilings or similar removeable concealment, equipment tags may be installed in the concealed space to reduce the amount of text in exposed sign.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General testing, adjustment, and balancing requirements.

B. Testing, adjustment, and balancing of air systems.

C. Testing, adjustment, and balancing of hydronic systems.

D. Testing, adjustment, and balancing of domestic water systems.

E. Sound and vibration measurement of equipment operating conditions.

F. This section excludes:

1. Testing boilers and pressure vessels for compliance with safety codes;
2. Specifications for materials for patching mechanical systems;
3. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.
4. Requirements and procedures for piping and ductwork systems leakage tests.

1.02 DEFINITIONS

A. TAB: Testing, adjusting, and balancing.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Data sheets arranged for collecting test data in logical order for submission and review. Data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. Examples include inlets and outlets on water terminals, inlets and outlets from air terminal units, and inlets and outlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the major or entire fluid flow of the system.

I. Submain: Duct or pipe containing part of the system capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.03 SUBMITTALS

A. Qualifications:

1. Submit qualifications of TAB agency.
2. Submit qualifications of TAB supervisor.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.

C. Sample Forms: Submit sample forms if they are other than the standard forms available from the certification association followed for the project.

D. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

E. Progress Reports.

F. Certified TAB Reports:

1. General:

a) Submit within two weeks after completion of testing, adjusting, and balancing.
b) Revise TAB plan to reflect actual procedures and submit as part of final report.
c) Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

2. Draft Report: Submit draft copies of report for review prior to final acceptance of Project. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
3. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports. The final report shall be certified proof of the following:

a) The systems have been tested, adjusted, and balanced in accordance with the referenced standards.
b) The report reflects an accurate representation of how the systems have been installed.
c) The report reflects a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures.
d) The report is an accurate record of all final quantities measured to establish normal operating values of the systems.

4. Report Format: Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, and cover identification at front and side. Include set of reduced size drawings indicating air outlets, equipment, and thermostat locations identified to correspond with report forms. Divide the report into the following divisions:

a) General Information and Summary

1) Include project name, location, altitude, and date.
2) Identify TAB agency, contractor, owner, architect, and engineer.
3) Include addresses, contact names, and telephone numbers.
4) Include certification sheet containing the seal, name, address, telephone number, and signature of the certified TAB Supervisor.
5) Include actual instrument list, with manufacturer name, serial number, and date of calibration.

b) Air Systems
c) Hydronic Systems
d) Temperature Control Systems
e) Special Systems
f) Sound and Vibration Systems

5. Report Forms: Standard forms prepared by the TAB certification standard being followed for each respective item and system to be tested, adjusted, and balanced. If not specified, follow ASHRAE 111.
6. Units of Measure: Report data in I-P (inch-pound) units only.

G. Project Record Documents: Provide drawings that record actual locations of flow measuring stations and balancing devices.

1.04 QUALITY ASSURANCE

A. Comply with ASHRAE Standard 111, Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.

B. Comply with ASHRAE Handbook, HVAC Applications Volume, Chapter "Testing, Adjusting, and Balancing", most current edition.

C. TAB Agency Qualifications:

1. Act as the single source of responsibility for TAB of the HVAC systems.
2. Staff the project at all times by qualified personnel.
3. Have a minimum of 5 years documented experience on projects with TAB requirements similar to those required for the project.
4. Certified by one of the following Certification Associations:

a) AABC (NSTSB): Associated Air Balance Council, National Standards for Total System Balance.
b) NEBB: National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
c) TABB: Testing, Adjusting, and Balancing Bureau, SMACNA TAB Procedural Guide.

D. TAB Supervisor and Technician Qualifications:

1. Certified by the same organization as TAB agency.
2. TAB Supervisor shall be a professional engineer licensed in the state in which the project is located.

E. Pre-Qualified TAB Agencies:

1. AccuTech
2. Doyle Field Services.
3. Precisionaire of the Midwest.
4. Pro Balance.
5. Total Air Balance.

PART 2 - PRODUCTS AND MATERIALS – NOT USED

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Begin work after systems to be tested, adjusted, or balanced are fully operational, duct systems are sealed, piping systems have been tested for leaks, and equipment is operational. Complete work prior to Substantial Completion of the project.

B. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems.

C. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

D. Coordinate with Division 22 drawings for testing, adjusting, and balancing scope of work.

E. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

F. Submit progress reports at least once a week to the General Contractor to communicate status of work so that the TAB work is completed in a timely manner.

G. Notice of Tests: Provide seven days advance notice for each test. Include scheduled test dates and times.

H. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

I. All required instrumentation shall be calibrated to tolerances specified in the referenced standards within a period of six months prior to starting the project.

3.02 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Motors and bearings are lubricated.
5. Final filters are clean and in place. If required, install temporary media in addition to final filters.
6. Duct systems are clean of debris.
7. Fans are rotating correctly and belts have tension.
8. Fire, smoke, fire/smoke, and volume dampers are in place and open.
9. Air coil fins are cleaned and combed.
10. Volume dampers are installed at locations needed for balancing the air systems.
11. Access doors are closed and duct end caps are in place.
12. Air outlets are installed and connected.
13. Visually inspect duct systems to ensure they are sealed and leakage is minimized.
14. Hydronic systems are flushed, filled, and vented.
15. Hydronic systems are tested for leaks.
16. Test ports, gauge cocks, thermometer wells, flow-control devices, and balancing valves are properly installed and that their location is accessible.
17. Pumps are rotating correctly.
18. Proper strainer baskets are clean and in place.
19. Service and balance valves are open.
20. Expansion tanks are not air bound and have appropriate charge.
21. Air vents are operating freely.

B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

C. Beginning of work means acceptance of existing conditions.

3.03 PREPARATION

A. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a coordination meeting with all installers whose work will be tested, adjusted, or balanced.

B. Furnish all instruments required for testing, adjusting, and balancing operations.

1. Verify all instruments have been calibrated.
2. Furnish instruments as recommended by the manufacturer for the TAB application.
3. Furnish instruments that are best suited to the function being measured.
4. Furnish instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

C. Furnish additional balancing devices as required for TAB to the appropriate contractor for installation.

D. Obtain copies of approved shop drawings of air handling equipment, terminal outlets, and temperature control diagrams.

E. Obtain manufacturer's fan and terminal device outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.

F. Determine best locations in main and branch ductwork for most accurate duct traverses.

G. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

3.04 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Balance main ducts and equipment to within plus or minus 5 percent of design airflow.

B. Air Outlets and Inlets: Balance branch ducts and terminal devices to within plus or minus 10 percent of design airflow.

C. Hydronic Systems: Balance to within plus or minus 5 percent of design flow.

3.05 RECORDING AND ADJUSTING

A. Record data regarding design conditions from contract documents and installed conditions from shop drawings including equipment identification number, model number, location, area served, manufacturer, model number, serial number, motor nameplate horsepower and rpm, fan rpm, capacity and electrical voltage, amps and phases.

B. For all systems measure and record the ambient conditions at the time of testing and balancing. Include the following:

1. Dry bulb temperature.
2. Relative humidity.
3. Cloud cover.
4. Wind speed.
5. Time.

C. Field Logs: Maintain written logs including:

1. Running log of events and issues.
2. Discrepancies, deficient or uncompleted work by others.
3. Contract interpretation requests.
4. Lists of completed tests.

D. Ensure recorded data represents actual measured or observed conditions.

E. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

F. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

G. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

H. Cut insulation around ductwork and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

I. Patch and seal insulation, vapor barrier, ductwork, and housings, using materials identical to those removed.

J. Seal ducts and piping and test and repair leaks.

K. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

L. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

M. Check and adjust systems approximately six months after final acceptance and submit report.

N. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive values are obtained.

O. Take all readings at eye level of the indicated value to prevent parallax.

P. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

Q. Take measurements in the system where best suited for the task.

R. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.06 AIR SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Check filters for cleanliness.

B. Check dampers (both volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.

C. Verify volume dampers are installed at locations needed for balancing the air systems.

D. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.

E. Determine best locations in main and branch ductwork for most accurate duct traverses.

F. Place outlet dampers in the full open position.

G. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

H. Lubricate all motors and bearings.

I. Check fan belt tension.

J. Check fan rotation.

K. Energize fan motors and adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude. Replace fan and motor pulleys as required to achieve design conditions.

L. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

M. Measure air quantities at air inlets and outlets.

N. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

O. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Affect volume control by duct internal devices such as dampers and splitters.

P. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

Q. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

R. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

S. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

T. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

U. Where modulating dampers are provided, take measurements and balance at design conditions. Balance variable volume systems at design air flow rate and at minimum air flow rate.

V. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship to maintain building pressure setpoint.

W. Multi-Zone units with Mixing Dampers: Check for motorized damper leakage. Adjust air quantities with mixing dampers set first at design cooling, then at design heating.

X. For variable air volume boxes, set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

Y. Procedure for establishing minimum and absolute minimum outdoor air damper position on air handling units:

1. Open the minimum outdoor air damper and return air damper fully. Close the economizer air damper.
2. Operate supply fan at design speed and measure the outdoor airflow.
3. If the outdoor airflow is above the scheduled minimum ventilation airflow, adjust the damper linkage on the minimum outdoor air damper so that outdoor airflow equals the scheduled minimum ventilation airflow with damper fully stroked.
4. If outdoor airflow is below the scheduled minimum ventilation airflow, adjust the damper linkage on the return air damper so that outdoor airflow equals the schedule minimum ventilation airflow with the damper fully stroked.
5. Convey the measured setpoint and/or damper position to the BAS installer and note on air balance report.
6. Repeat this procedure to determine damper position for absolute minimum ventilation.

3.07 HYDRONIC SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Open valves to full open position. Close coil bypass valves.

B. Remove and clean all strainers.

C. Check pump rotation.

D. Clean and set automatic fill valves for required system pressure.

E. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

F. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

G. Set temperature controls so all coils are calling for full flow.

H. Check operation of automatic bypass valves.

I. Check and set operating temperatures of chillers to design requirements.

J. Lubricate all motors and bearings.

K. Adjust water systems to provide required or design quantities.

L. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on correlated flow from temperature and pressure gauges across the heat transfer elements in the system.

M. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

N. Affect system balance with automatic control valves fully open to heat transfer elements.

O. Affect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

P. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

Q. Balance cooling tower water distribution systems to ensure even water flow to each tower cell.

R. Test cooling tower systems for capacity, recording pump flow and head, fan airflow, ambient air wet and dry bulb temperatures at tower inlet and outlet and tower inlet and outlet water temperatures.

S. Record the necessary information for optimizing pump operation as defined on the controls drawings. Give this information to the controls contractor for building automation system programming.

3.08 DOMESTIC WATER SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Before balancing the system perform these steps:

1. Open valves to full open position.
2. Examine plumbing system and equipment installations to verify that indicated balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices and balancing valves and fittings are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
3. Remove and clean all strainers.
4. Check pump rotation.
5. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
6. Lubricate all motors and bearings.

3.09 TESTING FOR SOUND AND VIBRATION

A. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards:

1. ASHRAE: ASHRAE Handbook, HVAC Applications Volume, Chapter “Sound and Vibration Control”, most current edition.
2. NEBB: "Procedural Standards for the Measurement and Assessment of Sound and Vibration."

B. Other than sound data, failure of an item includes a deviation of more than 10 percent from setpoint. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.

1. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

C. Prepare and submit report of recommendations for correcting any sound or vibration levels that are outside of manufacturer’s tolerances, ASHRAE standards and/or values specified in the contract documents.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Piping Insulation.

B. External Ductwork Insulation.

C. Equipment Insulation.

1.02 RELATED REQUIREMENTS

A. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields, pipe saddles, and high-density insulation inserts.

B. Division 23 Section “Buried Hydronic Piping,” for insulation of piping installed below grade.

C. Division 23 Section “Metal Ducts” for duct liner insulation.

1.03 DEFINITIONS

A. Cold Pipe: Piping that carries fluid with a minimum operating temperature less than 60 degrees F.

B. Hot Pipe: Piping that carries fluid with a minimum operating temperature greater than 105 degrees F.

C. Cold Duct: Ductwork that carries airflow with a minimum operating temperature less than 65 degrees F temperature.

D. Hot Duct: Ductwork that carries airflow with a minimum operating temperature greater than 75 degrees F temperature.

E. Neutral Ductwork: Ductwork that carries airflow with temperatures between the defined cold and hot temperatures.

F. Cold Equipment: Equipment that carries fluids with a minimum operating temperature less than 60 degrees F.

G. Hot Equipment: Equipment that carries fluids with a minimum operating temperature greater than 105 degrees F.

H. Exposed: Insulation that is visible from the occupied space.

I. Exposed to Weather: Insulation that is exposed to potential damage caused by weather, including sunlight, moisture, wind, and solar radiation.

J. Exterior: Locations outside of or within the building envelope (walls, roof, floors, etc) as defined by the architectural drawings and specifications.

K. Unconditioned Spaces: An enclosed space within a building that is not provided with mechanical heating or cooling.

1.04 SUBMITTALS

A. Product Data: Submit technical product data, thermal characteristics, and materials for each type of mechanical insulation.

B. Insulation Schedule: Include product name, conductivity k-value, thickness, and furnished accessories for each service.

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

D. Manufacturer's Instructions: Include installation instructions for storage, handling, protection, examination, preparation, and installation of the product.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualification: Company specializing in manufacturing the products specified in this section with not less than three years of documented experience.

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. Flame/Smoke Ratings: 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 UL 723 or ASTM E84 (NFPA 255) method.

1. Exception: Exterior mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
2. Exception: Industrial mechanical insulation that will not affect life safety egress of building may have flame spread index of 75 and smoke developed index of 150.
3. Exception: Polyisocyanurate insulation that is not installed in a return air plenum may have a flame spread index of 25 and smoke developed index of 450.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage; store in original wrapping.

1.07 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 - PRODUCTS

2.01 PIPING INSULATION MATERIALS

A. Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

   a) CertainTeed Corp.
   b) Johns Manville.
   c) Knauf Insulation.
   d) Owens Corning.

2. Insulation: ASTM C547, Type I or II, rigid mineral fiber, pre-formed for the application.

a) K-value: ASTM C518 or C177, maximum 0.24 at 75 degrees F.
b) Minimum Service Temperature: 0 degrees F
c) Maximum Service Temperature: 850 degrees F for Type I, 1200 degrees F for Type II.
d) Density: Between 3 to 6 pounds per cubic foot for Type I, between 6 to 8 pounds per cubic foot for Type II.

3. Factory Applied Jacket: ASTM C1136, Type I.

a) All-Service Jacket (ASJ): Paper/Foil/Scrim, water vapor permeance of 0.02 perms and self-sealing lap.
b) Poly ASJ: Paper/Foil/Scrim with polymer coating, water vapor permeance of 0.01 perms and self-sealing lap.
c) Color: White.

B. Cellular Glass:

1. Manufacturers:

a) Owens Corning.

2. Insulation: ASTM C552, Type II, Grade 6, rigid closed glass cells pre-formed for the application.

a) K-value: ASTM C518 or C177, maximum 0.34 at 75 degrees F.
b) Minimum Service Temperature: Minus 450 degrees F.
c) Maximum Service Temperature: 800 degrees F.
d) Density: Minimum 6.12 pounds per cubic feet.

C. Polyisocyanurate:

1. Manufacturers:

a) Dyplast Products.
b) Johns Manville.
c) Approved equal.

2. Insulation: ASTM C591, Grade 2, Type IV for ASTM E84 25/50 compliance, Type I for ASTM E84 25/450 compliance; rigid molded, pre-formed for the application.

a) K-value: ASTM C518 or C177, maximum 0.2 at 75 degrees F.
b) Minimum Service Temperature: Minus 297 degrees F
c) Maximum Service Temperature: 300 degrees F.
d) Density: Maximum 6 pounds per cubic feet.

D. Flexible Elastomeric:

1. Manufacturers:

    a) Aeroflex USA, Inc.
    b) Armacell LLC.
    c) K-Flex USA.

2. Insulation: ASTM C534, Grade I, flexible elastomeric cellular rubber insulation, pre-formed for the application.

    a) K-value: ASTM C518 or C177, maximum 0.28 at 75 degrees F.
    b) Minimum Service Temperature: Minus 297 degrees F
    c) Maximum Service Temperature: 220 degrees F for Grade I, 300 degrees F for Grade II.

3. Factory Applied Jacket:

    a) Polymeric Coating: Multi-ply, polymeric blend coating, 16 mils thick, designed to prevent damage to underlying insulation from sunlight, installation, and physical abuse, with water vapor permeance of 0.03 perms. Reference Piping Jacket Schedule in Part 3 of this specification for application of this jacket.

E. Field-Applied Jacket:

1. Canvas: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
2. Semi-rigid PVC: One-piece, pre-molded PVC cover conforming to ASTM D1784, including factory-furnished, pre-cut insulation blanket inserts for fittings.

    a) Outdoor Applications: Provide minimum 30 mils thickness and UV protection.
    b) Manufacturers:

        1) Johns Manville Zeston PVC Jacketing and 2000 Series Fitting Covers
        2) Proto Corp LoSmoke PVC Jacketing and Pro Fitting Covers.
        3) Or approved equal.

3. Rigid Aluminum Shell: One-piece, pre-formed cover conforming to ASTM C1729 with weather-proof construction. Shell shall have the following minimum thickness based on the outer insulation diameter:

Outer Insulation	Minimum Aluminum Jacket Thickness, (in)		
Diameter (in)	Non-Rigid Insulation	Rigid Insulation	Finish
≤ 8	0.016	0.016	Stucco
< 12	0.020	0.016	Stucco
≤ 24	0.024	0.016	Stucco
≤ 36	0.032	0.020	See Note 1

> 36	0.040	0.024	See Note 1

Note 1: Use corrugated finish for non-rigid insulation. Use stucco finish for rigid insulation.

a) Banding:

1) For piping less than or equal to 8 inches, provide 0.020 inch thick, 3/4 inch wide aluminum bands.
2) For piping larger than 8 inches, provide 0.020 inch thick, 3/4 inch wide stainless steel bands.

4. Multilayer Laminate Vapor Barrier Cladding: UV-resistant multi-ply outer layer and cold weather acrylic adhesive. Provide VentureClad Plus 1579 CW, or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 65 pounds per ASTM D1000.

5. Rubberized Asphalt Vapor Barrier Cladding: UV-resistant aluminum outer layer, multi-ply cross-laminated polyethylene film, and rubberized asphalt formulated for use on faced insulated duct and piping applications. Provide Polyguard Products, Inc. Alumaguard 60 mils thick cladding, Alumaguard Low Temp (LT) 35 mils thick cladding, or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 15 pounds per ASTM D1000.

6. Interior Vapor Barrier Membrane: Multi-ply, composite membrane of aluminum foil with polyester films on each side to protect the aluminum foil. Membrane shall be reversible to provide a clean, white finish on one side or smooth silver finish on the other side. Provide Polyguard Products, Inc. ZeroPerm or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 10 pounds per ASTM D1000.

F. Pipe Insulation Accessories: Provide staples, bands, wires, cement, and other appurtenances as recommended by insulation manufacturer for applications indicated.

G. Adhesives, Sealers, Mastics, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

1. Lagging Adhesive: Comply with MIL-A-3316C, Class 1, Grade A. Provide Foster 30-36, Childers CP-50AHV2, or equal.
2. Weather Barrier Breather Mastic: Permeance shall be 1.0 perms or less at 62 mils dry per ASTM E96, Procedure B. Provide Foster 46-50, Childers CP-10/11 or equal.

3. Solvent-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 35 mils dry per ASTM F 1249.
4. Water-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance in accordance with ASTM C755 for insulation application. Provide Foster 30-80, Childers CP-38, or equal.

Table: Recommended Maximum Permeance of Water Vapor Retarders (Note 1)

Insulation Application	Insulation Permeability, Less than 4.0 perm-in. (Note 2)	Insulation Permeability, 4.0 or greater perm-in. (Note 2)
	Vapor Retarder perms	Vapor Retarder perms
Pipe and vessels (33 F to ambient)	0.05	0.05
Pipe and vessels (-40 F to 32 F)	0.02	0.02
Ducts (40 F to ambient)	1.0	0.03

Notes:

1. Water vapor permeance of the vapor retarder in perms when tested in accordance with Test Methods E96.
5. Water vapor permeability of the insulation material when tested in accordance with Test Methods E96.

H. Insulation Diameters: Comply with ASTM C585 for inner and outer diameters of rigid thermal insulation.

I. Pipe, Valve and Fitting Covers: Comply with ASTM C450 for fabrication of fitting covers for pipe, valves and fittings.

J. High Density Insulation Billets:

1. Calcium Silicate: ASTM C533 and C795.
2. Flexible elastomeric: ASTM C534, Type 1.
3. Polystyrene: ASTM C578, Type XIII.

2.02 EXTERNAL DUCTWORK INSULATION MATERIALS

A. Flexible Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

a) CertainTeed Corp.
b) Johns Manville.
c) Knauf Insulation.
d) Owens Corning.

2. Insulation: ASTM C553, Type I or II, flexible mineral fiber blanket.

a) K-value: ASTM C518 or C177, maximum 0.31 at 75 degrees F.
b) Minimum Service Temperature: Minus 20 degrees F
c) Maximum Service Temperature: 450 degrees.
d) Density:

1) 1.5 pounds per cubic foot.

3. Factory Applied Vapor Barrier Jacket: ASTM C1136, Type II.

a) Foil Scrim Kraft (FSK): Kraft paper with glass fiber yarn and bonded to aluminized film, water vapor permeance of 0.02 perms and 2 inch stapling tab.
b) Polypropylene Scrim Kraft (PSK): Kraft paper with glass fiber yarn and bonded to metalized polypropylene, water vapor permeance of 0.02 perms and 2 inch stapling tab.
c) Color: Black.

B. Rigid Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

a) Johns Manville.
b) Knauf Insulation.
c) Owens Corning.

2. Insulation: ASTM C612, Type IA or IB, rigid mineral fiber board.

a) K-value: ASTM C518 or C177, maximum 0.25 at 75 degrees F.
b) Minimum Service Temperature: 0 degrees F
c) Maximum Service Temperature: 450 degrees.
d) Density:

1) 3.0 pounds per cubic foot.

3. Factory Applied Vapor Barrier Jacket: ASTM C1136, Type II.

a) All-Service Jacket (ASJ): Paper/Foil/Scrim, water vapor permeance of 0.02 perms.
b) Foil Scrim Kraft (FSK): Kraft paper with glass fiber yarn and bonded to aluminized film, water vapor permeance of 0.02 perms.
c) Polypropylene Scrim Polyester (PSP): Polyester paper with glass fiber yarn and bonded to polypropylene, water vapor permeance of 0.02 perms.
d) Color: White.

C. Cellular Glass:

1. Manufacturers:

a) Owens Corning.

2. Insulation: ASTM C552, Type I, Grade 6, rigid closed glass cells, block form.

a) K-value: ASTM C518 or C177, maximum 0.31 at 75 degrees F.
b) Minimum Service Temperature: Minus 450 degrees F.
c) Maximum Service Temperature: 800 degrees F.
d) Density: Minimum 6 pounds per cubic feet.

D. Polyisocyanurate:

1. Manufacturers:

a) Dyplast Products.
b) Johns Manville.
c) Approved equal.

2. Insulation: ASTM C591, Grade 2, Type IV for ASTM E84 25/50 compliance, Type I for ASTM E84 25/450 compliance; rigid board.

a) K-value: ASTM C518 or C177, maximum 0.2 at 75 degrees F.
b) Minimum Service Temperature: Minus 297 degrees F
c) Maximum Service Temperature: 300 degrees F.
d) Density: Maximum 6 pounds per cubic feet.

E. Flexible Elastomeric:

1. Manufacturers:

a) Aeroflex USA, Inc.
b) Armacell LLC.
c) K-Flex USA.

2. Insulation: ASTM C534, Grade 1, flexible elastomeric cellular rubber insulation, sheet form.

a) K-value: ASTM C518 or C177, maximum 0.28 at 75 degrees F.
b) Minimum Service Temperature: Minus 40 degrees F
c) Maximum Service Temperature: 180 degrees F.

3. Factory Applied Jacket:

a) Flexible Metal Cladding: Metallic factory-laminated cladding, 17.5 mils thick, designed to prevent damage to underlying insulation from sunlight, installation, and physical abuse, with water vapor permeance of 0.00 perms. Provide ArmaTuff or equal. Reference

Duct Jacket Schedule in Part 3 of this specification for application of this jacket.

F. Field-Applied Jacket:

1. Aluminum: ASTM B209, 3003 alloy, H-14 temper, with 3-mil thick polyfilm moisture barrier to interior surface.

a) Thickness: 0.032 inch sheet.
b) Finish: Smooth or Stucco. Reference Part 3 for jacket applications.
c) Joining: Longitudinal slip joints and 2 inch laps.
d) Fittings: 0.032 inch thick die shaped fitting covers with factory attached protective liner.
e) Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel.

2. Multilayer Laminate Vapor Barrier Cladding: UV-resistant multi-ply outer layer and cold weather acrylic adhesive. Provide VentureClad Plus 1579 CW, or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 65 pounds per ASTM D1000.

3. Rubberized Asphalt Vapor Barrier Cladding: UV-resistant aluminum outer layer, multi-ply cross-laminated polyethylene film, and rubberized asphalt formulated for use on faced insulation. Provide Polyguard Products, Inc. Alumaguard 60 mils thick cladding, Alumaguard Low Temp (LT) 35 mils thick cladding, or approved equal.

G. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, pins with insulation retaining washers, anchors, corner angles and other appurtenances as recommended by insulation manufacturer for applications indicated.

H. Adhesives, Sealers, Mastics, and Protective Finishes: Provide cements, adhesives, coatings, sealers, mastics, protective finishes, and similar compounds as recommended by insulation manufacturer for applications indicated.

1. Mineral Fiber Lagging Adhesive: Comply with ASTM C916, Type 2 or MIL-A-3316C, Class 2, Grade A. Provide Foster 85-60, Childers CP-127, or equal water-based adhesive.
2. Water-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 47 mils dry per ASTM E96. Provide Fosters 30-80, Childers CP-38, Design Polymerics 3040, or equal.
3. Solvent-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 35 mils dry per ASTM F 1249.

4. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

2.03 EQUIPMENT INSULATION MATERIALS

A. Flexible Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

   a) CertainTeed Corp.
   b) Johns Manville.
   c) Knauf Insulation.
   d) Owens Corning.

2. Insulation: ASTM C553, Type I and II or ASTM C547 Type II, flexible mineral fiber blanket.

   a) K-value: ASTM C518 or C177, maximum 0.31 at 75 degrees F.
   b) Minimum Service Temperature: Minus 20 degrees F
   c) Maximum Service Temperature: 450 degrees F for ASTM C553 Types I and II, 1200 degrees F for ASTM C547 Type II.
   d) Density: Minimum 1.5 pounds per cubic foot.

3. Factory Applied Vapor Barrier Jacket: ASTM C1136, Type II.

   a) Foil Scrim Kraft (FSK): Kraft paper with glass fiber yarn and bonded to aluminized film, water vapor permeance of 0.02 perms and 2 inch lap.
   b) Color: White.

B. Flexible Removeable and Reusable Blanket Insulation:

1. Manufacturers:

   a) Auburn Manufacturing.
   b) Approved equal.

2. Insulation: ASTM C553, Type V, flexible, noncombustible.

   a) Comply with ASTM C1695.
   b) K-value: ASTM C518 or C177, maximum 0.37 at 100 degrees F.
   c) Minimum Service Temperature: 32 degrees F
   d) Maximum Service Temperature: 500 degrees.

C. Rigid Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

a) Johns Manville.
b) Knauf Insulation.
c) Owens Corning.

2. Insulation: ASTM C612, Type IA or IB, rigid mineral fiber board.

a) K-value: ASTM C518 or C177, maximum 0.25 at 75 degrees F.
b) Minimum Service Temperature: 0 degrees F
c) Maximum Service Temperature: 450 degrees.
d) Density: Minimum 3.0 pounds per cubic foot.

3. Factory Applied Vapor Barrier Jacket: ASTM C1136, Type II.

a) All-Service Jacket (ASJ): Paper/Foil/Scrim, water vapor permeance of 0.02 perms.
b) Foil Scrim Kraft (FSK): Kraft paper with glass fiber yarn and bonded to aluminized film, water vapor permeance of 0.02 perms.
c) Color: White.

D. Cellular Glass:

1. Manufacturers:

a) Owens Corning.

2. Insulation: ASTM C552, Type I, Grade 6, rigid closed glass cells, block form.

a) K-value: ASTM C518 or C177, maximum 0.31 at 75 degrees F.
b) Minimum Service Temperature: Minus 450 degrees F.
c) Maximum Service Temperature: 800 degrees F.
d) Density: Minimum 6.12 pounds per cubic feet.

E. Flexible Elastomeric:

1. Manufacturers:

a) Aeroflex USA, Inc.
b) Armacell LLC.
c) K-Flex USA.

2. Insulation: ASTM C534, Grade I or II, flexible elastomeric cellular rubber insulation, sheet form.

a) K-value: ASTM C518 or C177, maximum 0.28 at 75 degrees F.
b) Minimum Service Temperature: Minus 40 degrees F

c) Maximum Service Temperature: 220 degrees F for Grade I, 300 degrees F for Grade II.

F. Field-Applied Jacket:

1. Canvas: UL listed, minimum 8 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
2. Aluminum: ASTM B209, 3003 alloy, H-14 temper, with 3-mil thick polyfilm moisture barrier to interior surface.

a) Thickness: 0.032 inch sheet.
b) Finish: Smooth.
c) Joining: Longitudinal slip joints and 2 inch laps.
d) Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel.

3. Stainless Steel: ASTM A666, Type 304 stainless steel.

a) Thickness: 0.010 inch sheet.
b) Finish: Smooth.
c) Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

4. Multilayer Laminate Vapor Barrier Cladding: UV-resistant multi-ply outer layer and cold weather acrylic adhesive. Provide VentureClad Plus 1579 CW, or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 65 pounds per ASTM D1000.

5. Rubberized Asphalt Vapor Barrier Cladding: UV-resistant aluminum outer layer, multi-ply cross-laminated polyethylene film, and rubberized asphalt formulated for use on faced insulation. Provide Polyguard Products, Inc. Alumaguard 60 mils thick cladding, Alumaguard Low Temp (LT) 35 mils thick cladding, or approved equal.
6. Interior Vapor Barrier Membrane: Multi-ply, composite membrane of aluminum foil with polyester films on each side to protect the aluminum foil. Membrane shall be reversible to provide a clean, white finish on one side or smooth silver finish on the other side. Provide Polyguard Products, Inc. ZeroPerm or approved equal.

a) Water Vapor Transmission: 0.0 perms per ASTM E96.
b) Puncture Resistance: Minimum 10 pounds per ASTM D1000.

G. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors, stud pins, and other appurtenances as recommended by insulation manufacturer for applications indicated.

H. Adhesives, Sealers, Mastics, and Protective Finishes: Provide cements, adhesives, coating, sealers, mastics, and protective finishes as recommended by insulation manufacturer for applications indicated.

1. Mineral Fiber Lagging Adhesive: Comply with ASTM C916, Type 2 or MIL-A-3316C, Class 2, Grade A. Provide Foster 85-60, Childers CP-127, or equal water-based adhesive.
2. Water-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 47 mils dry per ASTM E96. Provide Foster 30-80, Childers CP-38, Design Polymerics 3040, or equal.
3. Lagging Adhesive: Comply with MIL-A-3316C, Class 1, Grade A. Provide Foster 30-36. Childers CP-50AHV2 or equal.
4. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Test piping and ductwork for design pressure, liquid tightness, and continuity prior to applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 PROTECTION AND REPLACEMENT

A. Provide all required protection for insulation (installed and uninstalled) throughout the duration of construction to avoid exposure to plaster, dust, dirt, paint, moisture, deterioration, and physical damage.

B. Repair existing mechanical insulation that is damaged during this construction period. Use insulation of same type and thickness as existing insulation. Install new jacket lapping and sealed over existing.

C. Replace damaged insulation which cannot be repaired satisfactorily at no additional expense to the Owner, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation. Drying the insulation is not acceptable. Dry surfaces prior to installation of new insulation that replaces the damaged or wet insulation.

3.03 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

3.04 PIPING SYSTEM INSULATION INSTALLATION

A. Maintain continuous thermal and vapor-retarder integrity throughout entire installation and protect it from puncture and other damage.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Exposed Piping: Locate insulation and cover seams in least visible locations.

E. Cold Pipe Insulation:

1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
2. Provide vapor barrier jacket according to the Piping Jacket Schedule.
3. Provide high density insulation material under supports or pre-insulated supports. Protect insulation with shields to prevent puncture or other damage. Refer to Section “Hangers & Supports for HVAC Piping & Equipment” for pre-insulated supports and insulation shields. and for exception where high density insulation inserts are not required.
4. High density insulation material shall extend a minimum 2 inches past the pipe shield on each side.
5. Secure all-service jacket with self-sealing longitudinal laps.
6. Butt pipe insulation tightly at insulation joints. Apply wet coat of vapor barrier lap cement on joint and seal with 3 inch wide vapor barrier tape or band and coat all taped seams and staple penetrations with vapor barrier coating to prevent moisture ingress.

F. Hot Pipe Insulation:

1. Insulate entire system, including fittings, valves, unions flanges, strainers, flexible connections, pump bodies, and expansion joints.

2. Provide jackets without vapor barrier according to the Piping Jacket Schedule. Jackets with vapor barrier are allowed.
3. Provide high density insulation material or pre-insulated supports where supports are installed outside of the insulation. Protect insulation with shields to prevent puncture or other damage. Refer to Section “Hangers & Supports for HVAC Piping & Equipment” for pre-insulated supports and insulation shields and for exception where high density insulation inserts are not required.
4. High density insulation material shall extend a minimum 2 inches past the pipe shield on each side.
5. Secure all-service jacket with self-sealing longitudinal laps.
6. Butt pipe insulation tightly at insulation joints and wrap insulation around supports. Apply 3 inch wide vapor barrier tape or band over joint.

G. Insulation of Fittings, Valves, Strainers, Flanges, and Unions:

1. Insulate fittings, joints, and valves with molded insulation of like material, vapor barrier coating, and thickness as adjacent pipe. Provide pre-formed insulation pieces, segmented insulation, or sectional pipe insulation for the application. Provide the same insulation jacket as adjoining pipe.
2. Sectional pipe insulation: Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Hold sectional cuts in place with tie wire or bands. Wire and bands shall be compatible with insulation and jacket.
3. Segmented pipe insulation: Cover segmented insulated surfaces with a layer of finishing cement and finish with a coating or mastic. Reinforce the mastic with fabric-reinforcing mesh. Trowel the coating or mastic to a smooth and well-shaped contour.
4. Butt each insulation piece tightly against adjoining piece of insulation. Bond pieces together according to Cold Pipe or Hot Pipe installation instructions.
5. Insulate valves up to and including the bonnets, valve stuffing-box studs, bolts, and nuts with a removeable insulation cover. Sectional valve insulation covers shall divide the section along the vertical center line of the valve body.
6. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover.
7. Insulate flanges and unions with a removeable insulation cover. Sectional pipe insulation covers shall divide the section along the center line of pipe.
8. When removeable covers are made from sectional block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, around the insulated device with tie wire. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

9. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation. PVC fitting covers with end caps are also acceptable. Tape PVC covers to adjoining insulation facing using PVC tape.
10. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

I. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated. Maintain vapor barrier through the penetration.

J. Exterior Piping and Piping Exposed to Weather:

1. General: Provide piping jacket around insulation as scheduled in the Piping Jacket Schedule. Jacket material shall be approved by the jacket manufacturer for use with the specific insulation material that it covers. Locate longitudinal seams of outer shell (aluminum, flexible elastomeric, or cladding as applicable) at bottom of pipe. Provide insulation shields so that the piping supports cannot puncture, cut or break the jacket.
2. Paintable Coating: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
3. Polymeric Coating: Provide insulation shields so that the piping supports do not puncture, cut or break the jacket.
4. Rigid aluminum shell: Space attachment bands 12 inches on center and directly centered over end joints.
5. Multilayer Laminate Vapor Barrier Cladding: Install cladding only when ambient temperature is above 50 degrees F. Provide low-temp products for installation in low ambient temperatures down to 10 degrees F.
6. Rubberized Asphalt Vapor Barrier Cladding: Install cladding for use in ambient temperatures as low as minus 10 degrees F.

3.05 PIPING SYSTEM INSULATION SCHEDULE

A. Reference Pipe Insulation Thickness Schedule at the end of this specification for thickness requirements based on insulation conductivity.

B. Do not apply insulation to piping that operates outside of the minimum and maximum service temperature range.

C. Omit insulation on the following:

1. Hot piping within radiation enclosures or unit cabinets.
2. Cold piping within unit cabinets provided piping is located over drain pan.
3. Heating piping between coil and shutoff valves provided piping is located within heated space and not more than three feet from coil.
4. Condensate piping between steam trap and union.
5. Flexible connections and expansion joints in pipes with fluids above ambient temperatures.

D. Exterior Piping: Insulate all exterior HVAC piping with one of the following:

1. Cellular glass.
2. Flexible elastomeric, use high temperature formula for systems with operating temperatures above 220 F. (not acceptable for steam, steam condensate or hot water piping systems with temperatures above 300 F).

E. Cold Piping (40 degrees F (4.4 degrees C) to 60 degrees F):

1. Service:

a) Chilled water supply and return piping.
b) Air conditioner condensate drain piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a) Mineral fiber.
b) Cellular glass.
c) Polyisocyanurate.
d) Flexible elastomeric.

F. Warm Temperature Piping (105 degrees to 140 degrees F (40 to 94 degrees C)):

1. Service:

a) Heating hot water supply and return piping.

2. Insulate each piping system specified above with one of the following types of insulation.

a) Mineral fiber.
b) Cellular glass.
c) Polyisocyanurate.

d) Flexible elastomeric.

3.06 PIPE INSULATION THICKNESS SCHEDULE

A. IECC – 2018 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid Operating Temp. Range (°F) And Usage	Insulation Conductivity: Conductivity, Btu·in./(hr·ft²·°F)	Insulation Conductivity: Mean Rating Temp., °F.	Nominal Pipe or Tube Size (in.): <1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
>350°F	0.32–0.34	250	4.5	5.0	5.0	5.0	5.0
251°F–350°F	0.29–0.32	200	3.0	4.0	4.5	4.5	4.5
201°F–250°F	0.27–0.30	150	2.5	2.5	2.5	3.0	3.0
141°F–200°F	0.25–0.29	125	1.5	1.5	2.0	2.0	2.0
105°F–140°F	0.21–0.28	100	1.0	1.0	1.5	1.5	1.5
40°F–60°F	0.21–0.27	75	0.5	0.5	1.0	1.0	1.0
<40°F	0.20–0.26	50	0.5	1.0	1.0	1.0	1.5

Notes:

a) For piping smaller than 1-1/2 inch and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch.

b) For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r[(1 + t/r)^{(K/k)} – 1]$ where

1) T = minimum insulation thickness (in.),
2) r = actual outside radius of pipe (in.),
3) t = insulation thickness listed in the table for applicable fluid temperature and pipe size,
4) K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in/hr·ft²·°F); and
5) k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

c) Insulation thicknesses are based on energy efficiency considerations only. Add insulation where noted on the drawings.

d) For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

e) The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance greater than that of steel pipe, reduced thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown on the table.

3.07 PIPING JACKET SCHEDULE

A. Exposed piping within mechanical rooms (below 10 feet):

1. Semi-rigid PVC.
2. Rigid aluminum shell.

B. Exposed piping within mechanical rooms (above 10 feet):

1. Canvas.
2. Semi-rigid PVC.
3. Rigid aluminum shell.

C. Exposed piping:

1. All-service jacket.
2. Canvas.
3. Semi-rigid PVC.

D. Piping within return air plenums:

1. All-service jacket.
2. Canvas.

E. Exterior piping and piping exposed to weather:

1. Paintable coating (flexible elastomeric insulation only.)
2. Polymeric Coating (flexible elastomeric insulation only).
3. Semi-rigid PVC for outdoor application(flexible elastomeric insulation on refrigerant piping only).
4. Rigid aluminum shell.
5. Multilayer laminate vapor barrier cladding.
6. Rubberized asphalt vapor barrier cladding.

3.08 DUCTWORK INSULATION SYSTEM INSTALLATION

A. Maintain continuous thermal and vapor-barrier integrity throughout entire installation and protect it from puncture and other damage.

B. Install insulation on duct systems subsequent to painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces.

D. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Install insulation without sag on underside of duct. Where rectangular ducts are 24 inches in width or greater, secure external insulation to the bottom of the duct with mechanical fasteners, spaced on 18 inches on center (maximum). Fasteners shall include 2-inch square self-sticking galvanized carbon-steel base plates with minimum 0.106-inch diameter zinc-coated, low carbon steel, fully annealed shank spindle, length to suit depth of insulation. Secure insulation to spindles with self-locking washers incorporating a spring steel insert to ensure permanent cap retention. Lift duct off trapeze hangers and insert spacers to avoid insulation compression.

F. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

G. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

H. Lined Ductwork: At interface of lined and wrapped ductwork, overlap lined ductwork by 2 feet (minimum) with wrapped insulation.

I. Cold Ducts:

1. Insulate entire system, including fittings, joints, flanges, expansion joints, and air duct accessories.
2. Provide vapor barrier jacket according to the Ductwork Jacket Schedule.
3. Seal joints with vapor barrier mastic.
4. Continue insulation, including vapor barrier, through walls, sleeves, hangers, and other duct penetrations.
5. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
6. Where cold ducts are installed in mechanical rooms or non-conditioned spaces (excludes return air plenums), prevent condensation from forming on the duct supports by providing one or more of the following:

    a) Install thermal break such as rigid board insulation between the support and duct.

b) Wrap support that is in contact with the duct with external duct wrap insulation to prevent condensation. Wrap shall extend a minimum of 12 inches from point of contact of the support with the duct. Tape joints to provide a thermal and vapor barrier. Coat all taped joints, punctures and seams with 4 inch wide coating of vapor barrier mastic.

c) If a support device similar to Unistrut is used, foam fill or stuff tube.

J. Hot and Neutral Ducts:

1. Insulate entire system, including fittings, joints, flanges, expansion joints, and air duct accessories.
2. Provide jackets with or without vapor barrier according to the Ductwork Jacket Schedule.
3. Secure joints with staples, tape, or wires.
4. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

K. Exterior Ductwork and Ductwork Exposed to Weather:

1. Slope ductwork to ensure that water cannot pond anywhere on the duct. Do not vary the insulation thickness to achieve drainage.
2. Jackets shall be approved by the jacket manufacturer for use with the specific insulation material it covers.
3. Locate longitudinal seams of jacket at bottom of duct. Install jacket in strict conformance with cladding manufacturer’s instructions.
4. Seal joints with vapor barrier mastic and reinforcing mesh as recommended by manufacturer or protective jacket as specified.
5. Install aluminum jacket with three metal jacket bands per section.
6. Multilayer Laminate Vapor Barrier Cladding: Install cladding only when ambient temperature is above 50 degrees F. Provide low-temp products for installation in low ambient temperatures down to 10 degrees F.
7. Rubberized Asphalt Vapor Barrier Cladding: Install cladding for use in ambient temperatures as low as minus 10 degrees F.
8. Cover seams in flexible metal cladding with ArmaTuff seal tape or equal.

3.09 DUCTWORK SYSTEM INSULATION SCHEDULE

A. Omit insulation on the following:

1. Fibrous glass ductwork (ductboard).
2. Lined ductwork.
3. Ductwork with sound absorbing linings.

B. Prohibited insulation:

1. Polyisocyanurate installed within a return air plenum.

C. Outdoor Air:

1. Service:

a) Interior untreated outdoor air intake ducts.
b) Pre-conditioned outdoor air ducts.
c) Combustion air intake ducts.

2. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.
d) Polyisocyanurate.
e) Flexible elastomeric.

D. Supply Air:

1. Service:

a) Supply ducts from air handling equipment.
b) Insulate neck and bells of supply diffusers.

2. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.
d) Polyisocyanurate.
e) Flexible elastomeric.

E. Return Air:

1. Service:

a) Interior ductwork within 10 feet of exterior roof or wall penetrations.
b) Interior ductwork routed through or from unconditioned spaces and plenums.

2. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.

d) Polyisocyanurate.
e) Flexible elastomeric.

F. Exhaust Air.

1. Service:

a) Interior ductwork within 10 feet of exterior roof or wall penetrations.
b) Interior ductwork routed through conditioned spaces (excludes ductwork routed in shafts) that is exhausting from unconditioned spaces (such as loading docks, garages, etc.).
c) Interior ductwork downstream of heat recovery device (wheel, plate, heat pipe, etc.) to exterior discharge outlet.
d) Exterior ductwork upstream of heat recovery device (wheel, plate, heat pipe, etc.).
e) Range and kitchen hood non-grease exhaust ductwork.
f) Dishwasher exhaust ducts within 10 feet of discharge to the outdoors.

2. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.
d) Polyisocyanurate.
e) Flexible elastomeric.

G. Range and hood grease exhaust ductwork: Refer to Section “Air Duct Accessories” for requirements of fire-rated wrap insulation for grease exhaust duct.

H. Relief Air.

1. Service:

a) Interior ductwork within 10 feet of exterior roof or wall penetrations.
b) Downstream of heat recovery device (wheel, plate, heat pipe, etc.) to exterior discharge outlet.

2. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.
d) Polyisocyanurate.

e) Flexible elastomeric.

I. HVAC plenums and unit housings not pre-insulated at factory or lined.

1. Acceptable Insulation:

a) Flexible mineral fiber.
b) Rigid mineral fiber.
c) Cellular glass.
d) Polyisocyanurate.
e) Flexible elastomeric.

J. Exterior Ductwork:

1. Service:

a) Supply ductwork.
b) Return ductwork.
c) Exhaust ductwork.
d) Pre-conditioned outside air downstream of conditioning unit.
e) Plenums and unit housings not pre-insulated at factory or lined.

2. Acceptable Insulation:

a) Cellular glass.
b) Polyisocyanurate.
c) Flexible elastomeric.
d) Omit insulation on phenolic foam ductwork and fittings. Refer to Division 23 Section “Nonmetal Ducts.”

3.010 DUCT SYSTEM INSULATION THICKNESS SCHEDULE

A. Flexible Mineral Fiber:

1. Interior Ductwork:

a) 1.5 pounds per cubic foot density:

1) 1-1/2 inch thick, minimum R-4.2.

2. Meet R-value installed at maximum 25% compression, application limited to concealed locations.

B. Rigid Mineral Fiber:

a) 3 pounds per cubic foot density:

1) 1 inch thick, minimum R-4.2.

2. Ductwork installed in machine, fan, and mechanical equipment rooms:

    a) 2 inch thick, minimum R-8.0.

3. Ductwork Exposed to Weather, or Ductwork:

    a) 2 inch thick, minimum R-8.0.

4. Ductwork in an Unconditioned Space:

    a) 1-1/2 inch thick, minimum R-6.0.

C. Cellular Glass:

1. Interior Ductwork:

    a) 1-1/2 inch thick, minimum R-5.0.

2. Ductwork Exposed to Weather, or Ductwork:

    a) 2-1/2 inch thick, minimum R-8.0.

3. Ductwork in an Unconditioned Space:

    a) 2 inch thick, minimum R-6.0.

D. Polyisocyanurate:

1. Interior Ductwork:

    a) 1 inch thick, minimum R-6.0.

2. Ductwork Exposed to Weather:

    a) 1-1/2 inch thick, minimum R-8.0.

3. Ductwork in an Unconditioned Space:

    a) 1 inch thick, minimum R-6.0.

E. Flexible Elastomeric:

1. Interior Ductwork:

    a) 1 inch thick, minimum R-4.2.

2. Ductwork Exposed to Weather:

    a) 2 inch thick, minimum R-8.0.

3. Ductwork in an Unconditioned Space:

a) 1-1/2 inch thick, minimum R-6.0.

3.011 DUCTWORK JACKET SCHEDULE

A. Omit jacket on internally lined ductwork.

B. Exposed ductwork within mechanical rooms (below 10 feet):

1. Foil Scrim Kraft (FSK).
2. Polypropylene Scrim Kraft (PSK).
3. All-Service Jacket (ASJ).
4. Polypropylene Scrim Polyester (PSP).
5. Flexible Metal Cladding (flexible elastomeric only).
6. Aluminum with smooth finish.

C. Exposed ductwork within mechanical rooms (above 10 feet):

1. Foil Scrim Kraft (FSK).
2. Polypropylene Scrim Kraft (PSK).
3. All-Service Jacket (ASJ).
4. Polypropylene Scrim Polyester (PSP).
5. Flexible Metal Cladding (flexible elastomeric only).

D. Exposed ductwork:

1. Foil Scrim Kraft (FSK).
2. Polypropylene Scrim Kraft (PSK).
3. All-Service Jacket (ASJ).
4. Polypropylene Scrim Polyester (PSP).
5. Flexible Metal Cladding (flexible elastomeric only).
6. Aluminum with smooth finish.

E. Ductwork within return air plenums:

1. Foil Scrim Kraft (FSK).
2. Polypropylene Scrim Kraft (PSK).
3. All-Service Jacket (ASJ).
4. Polypropylene Scrim Polyester (PSP).
5. Flexible Metal Cladding (flexible elastomeric only).

F. Ductwork in an unconditioned space:

1. Foil Scrim Kraft (FSK).
2. Polypropylene Scrim Kraft (PSK).

3. All-Service Jacket (ASJ).
4. Polypropylene Scrim Polyester (PSP).
5. Flexible Metal Cladding (flexible elastomeric only).

3.012 EQUIPMENT INSULATION INSTALLATION

A. Install insulation subsequent to painting, testing, and acceptance of tests.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Protect insulation to prevent puncture and other damage.

D. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

E. Do not apply insulation to equipment, breechings, or stacks while hot.

F. Do not insulate flanges and unions of equipment carrying fluids less than 105 degrees F.

G. Provide neatly beveled edge at interruptions of insulation.

H. Fasten insulation to equipment with studs, pins, clips, adhesives, wires, or bands.

I. Stagger insulation joints for both single and double layer application, where feasible. Apply each layer of insulation separately. Tape all joints using glass cloth or a suitable, matching acrylic adhesive tape; minimum 3 inches wide.

J. Coat insulated surfaces of calcium silicate with layer of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

K. Cover insulated surfaces with jacketing, factory or field applied, neatly fitted and firmly secured. Lap seams at least 2 inches. Apply over vapor barrier where applicable. Tape all joints using glass cloth or a suitable, matching acrylic adhesive tape; minimum 3 inches wide.

L. Cold Equipment:

1. Insulate entire system, including flanges and unions. Maintain continuous vapor-barrier integrity throughout entire installation and protect it from puncture and other damage.
2. Provide vapor barrier jacket, factory or field applied over mineral fiber insulation. Finish with glass cloth or vapor barrier adhesive.
3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.

M. Hot Equipment:

1. Insulate entire system, including flanges and unions.
2. Provide jacket, with or without vapor barrier, factory or field applied over mineral fiber insulation. Finish with glass cloth or vapor barrier adhesive.

3.013 EQUIPMENT INSULATION SCHEDULE

A. Omit Insulation on the following:

1. Boiler manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplates.
2. Factory pre-insulated equipment.

B. Do not apply insulation to equipment that operates outside of the minimum and maximum service temperature range.

C. Provide flexible removable and reusable blanket insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

D. Cold Equipment:

1. Service:
   a) Cold surfaces not factory insulated.
   b) Drip pans under chilled equipment.
   c) Chilled water expansion tanks, air separators and piping accessories.
   d) Chilled water pumps.
2. Acceptable Insulation:
   a) Flexible Mineral Fiber:
      1) 2 inch thick for cold surfaces above 35 degrees F.
   b) Rigid Mineral Fiber:
      1) 2 inch thick for cold surfaces above 35 degrees F.

c) Cellular Glass:

1) 3 inch thick for surfaces above 35 degrees F.

d) Flexible Elastomeric:

1) 3 inch thick for surfaces above 35 degrees F.

E. Hot Equipment:

1. Service:

a) Boilers.
b) Hot water expansion tanks, air separators, and piping accessories.
c) Hot water pumps.
d) Boiler feedwater storage tanks.
e) Deaerators.

2. Acceptable Insulation:

a) Flexible Mineral Fiber:

1) 2 inch thick for all other applications.

b) Rigid Mineral Fiber:

1) 2 inch thick for all other applications.

F. Breechings, Chimneys, and Stacks:

1. Service:

a) Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.
b) Stack from bottom to top except for factory insulated stacks.

2. Acceptable Insulation:

a) Flexible Mineral Fiber: 2 inch thick.
b) Calcium Silicate: 2 inch thick.

G. Generator Exhaust:

1. Service:

a) Emergency generator exhaust piping from generator outlet to discharge.

2. Acceptable Insulation: Insulate each generator exhaust with one of the following types and thicknesses of insulation.

    a) Flexible Mineral Fiber (ASTM C547 Type II only): 2 inch thick.
    b) Calcium Silicate: 2 inch thick.

3.014 EQUIPMENT JACKET SCHEDULE

A. Omit jacketing on equipment pre-insulated and jacketed from the factory.

B. Interior Equipment (all except flexible elastomeric insulation):

1. Canvas.
2. Aluminum.
3. Stainless steel.

C. Equipment in unconditioned spaces (all except flexible elastomeric insulation):

1. Canvas.
2. Aluminum.
3. Stainless steel.

D. Exterior Equipment or Equipment Exposed to Weather:

1. Aluminum.
2. Stainless Steel.
3. Multilayer Laminate Vapor Barrier Cladding.
4. Rubberized Asphalt Vapor Barrier Cladding.

E. Exterior Generator Exhaust or Generator Exhaust Exposed to Weather:

1. Aluminum.
2. Stainless Steel.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Control panels.

B. Control valves.

C. Control dampers.

D. Operators.

E. Flow measuring apparatus.

F. Humidistats.

G. Input/Output sensors and transmitters.

H. Output control devices.

I. Power Supplies.

J. Thermostats.

K. Time clocks.

L. Weather stations.

1.02 DEFINITIONS

A. BAS: Building Automation System.

B. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operations

C. Cv: Design Valve Flow Coefficient.

D. DDC: Direct Digital Control.

E. EPDM: Ethylene Propylene Diene Monomer.

F. High voltage: 50 volts or higher.

G. Low voltage: Below 50 volts.

H. PTFE: Polytetrafluoroethylene.

I. TEFZEL: A modified ETFE (ethylene tetrafluoroethylene) fluoroplastic.

1.03 CONTRACTOR RESPONSIBILITIES

A. Reference Division 23 Section ”Electrical Coordination for Mechanical Equipment” for contractor responsibilities.

B. BAS Contractor:

1. Installation of the BAS shall be by the BAS Contractor or their subcontractors.
2. Low voltage control wiring.
3. Coordinate high voltage control wiring to instrumentation and control devices with Division 26. Where high voltage power is required for instrumentation and control devices that is in addition to what is shown on the drawings, the BAS contractor shall cover the cost of providing this wiring.
4. All interlock wiring regardless of voltage (e.g., exhaust fan interlocked to supply fan).
5. Coordinate with Division 26 that motor starters are provided with auxiliary contacts as required for interlocks.
6. Coordinate power wiring to BAS controllers and instrumentation and control devices with Division 26.
7. Coordinate installation of back-box rough-in for wall-mounted control devices sensors, etc. with Division 26. Coordinate with mechanical contractor all locations, quantities, and sizes required for installation by Division 26.
8. Perform startup and demonstration services as specified in Section “Direct Digital Control for HVAC”.

C. Sheet Metal Contractor:

1. Installation of automatic control dampers, smoke control dampers, and necessary blank off plates.
2. Access doors where and as required.

D. Mechanical Contractor:

1. Installation of immersion wells.
2. Installation of flow switches.
3. Installation of automatic control valves.
4. Installation of pressure tappings and associated shut-off cocks.
5. Coordinate conduit and wall box rough-in, power wiring and magnetic starter requirements for controls and mechanical equipment with Division 26.

1.04 SUBMITTALS

A. Refer to Division 01 for submittal procedures.

B. Product Data: Provide description and engineering data for each control system component. Include dimensions, capacities, size, performance characteristics, electrical characteristics, and finishes of materials.

C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

D. Schedule for control valves and actuators, including the following:

1. Tag.
2. Quantity.
3. Model number.
4. Equipment served.
5. Flow at project design conditions.
6. Selected valve flow coefficient (Cv). For butterfly valves, submit the corresponding valve position at which the Cv is calculated.
7. Pressure differential drop across valve at project design flow conditions and selected Cv.
8. Maximum close-off pressure.
9. Valve Configuration (2-way/3-way).
10. Valve Normal Position and Fail Position (e.g., NO/FO; normally open/fail open).
11. Valve Size.
12. Line Size.
13. Valve Type.
14. Actuator Signal Type (Open/Close, Modulating 0-10 Vdc, 2-10 Vdc, 4-20 mA, etc.)
15. Torque required to close valve at pump shutoff head.
16. Selected actuator maximum torque output.

E. Manufacturer's Instructions: Provide for all manufactured components.

F. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

G. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

H. Warranty: Submit manufacturer warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

C. Control valves shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ANSI and MSS standards.

D. Measurement devices and sensors shall be calibrated using NIST traceable standards.

1.06 WARRANTY

A. Correct defective Work within a one year period after Substantial Completion.

B. Provide extended warranty for control devices and equipment as specified herein.

PART 2 - PRODUCTS

2.01 CONTROL PANELS

A. Construction:

1. Panel shall be UL 508A listed.
2. NEMA 250, general purpose utility enclosures with enameled finished face panel.
3. NEMA 4X utility enclosure for outdoor or wash-down applications.
4. Provide common keying for all panels.

2.02 CONTROL VALVES

A. General:

1. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Each valve shall be equipped with proper packing to ensure there will be no leakage at the valve stem.
2. Pressure Ratings:

   a) Valve body and packing rated to withstand the system static head plus the maximum pump head and the maximum temperature of the control medium (i.e. chilled water, steam, hot water, etc.).

      1) Minimum pressure class 150 psig.

b) Two-way modulating valves and their operators shall have close-off pressure ratings exceeding the dead-head condition of the pump in the system it serves.

c) Two-way modulating valves with equal percentage flow characteristics and their operators shall be rated to safely operate within a differential pressure range between 2 and 50 psi across the valve without cavitating.

3. Sizing:

a) Hydronic Systems:

1) Two-Position: Line size or sized using a pressure differential of 1 psi. Size butterfly valves using the 90 degree flow coefficient (Cv).

2) Modulating: Select valves with an appropriate flow coefficient (Cv) to achieve a minimum design valve authority of 0.5 relative to the total pressure drop of the piping branch the valve controls. Calculate Cv based on the larger of the following:

a) 5-psig pressure drop at the design flow rate specified in the Schedules.

b) Twice the equipment design pressure drop as specified in the Schedules unless otherwise noted:

i) Specific Equipment Pressure Drop (ft H_2O):

Chiller Head Pressure Control	5

c) Valve shall not be less than 1/2 Inch in size.

d) Size butterfly valves using the 60 degree of full open flow coefficient (Cv).

4. Flow Characteristics:

a) Hydronic Service:

1) Two-way valves: Equal percentage characteristic.

2) Chiller isolation valves: Linear characteristic.

5. End Connections:

a) Reference the Control Valve Schedule in Part 3 for allowable end connections by pipe material.

b) Carbon steel and stainless steel valves shall comply with ASME B16.34.

c) Comply with ASME B16.10 for face-to-face and end-to-end dimensions.

d) Threads:

1) Comply with ASME B1.20.1.

2) Comply with ASME B16.4 for cast iron.

3) Comply with ASME B16.15 for cast copper alloys, including bronze and brass.

e) Flanges:

1) Comply with ASME B16.5 for steel.
2) Comply with ASME B16.1 for cast iron
3) Comply with ASME B16.24 for cast copper alloys, including bronze and brass.

f) Grooved Fittings:

1) Water services to 230 deg F and 250 psig.

B. Globe Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size and end connection by application.
2. Construction:

a) Up to 2 inches: Class 150, ASTM B62 bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

1) Bronze body and bonnet shall conform to ASTM B62 up to pressure class 150. Conform to ASTM B61 for pressure class 200 and higher.

b) Over 2 Inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.

1) Iron body and bonnet shall conform to ASTM A126, class B.

c) Bonnet:

1) Bronze body, Class 125: Threaded type.
2) Bronze body, Class 150 or higher: Union type.
3) Iron body: Bolted type.

d) Disc Material:

1) PTFE.
2) Stainless steel.

e) Stem: Outside screw and yoke. Include extension for insulation.
f) Two-piece brass packing gland assembly, non-asbestos composition packing.

3. Rangeability: Minimum 50:1.
4. Leakage:

a) Up to 1-1/4 Inch: Minimum ANSI Class III per ANSI/FCI 70-2.
b) 1-1/2 Inch and Larger: Minimum ANSI Class IV per ANSI/FCI 70-2.

5. Design and Testing:

    a) MSS SP-80 for bronze.
    b) MSS SP-85 for cast iron.

C. Ball Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:

    a) Body:

        1) Bronze conforming to ASTM B61, B62, and B584.
        2) Forged brass with or without nickel plating conforming to ASTM B283.
        3) Cast carbon conforming to ASTM A216.
        4) Cast iron according to ASTM A126.
        5) Stainless steel conforming to ASTM A351.

    b) Up to 2 inches: Two-piece construction
    c) 2-1/2 inch to 3 inch: Three-piece construction.
    d) Stainless steel, blowout proof stem. Include extension for insulation.
    e) Replaceable PTFE seats and EPDM O-ring or PTFE packing seals.

3. Ball: Full port with characterized insert comprised of the following material:

    a) Stainless steel.
    b) Chrome-plated.
    c) Nickel-plated.

4. Rangeability: Minimum 50:1.
5. Leakage: Minimum ANSI Class IV per ANSI/FCI 70-2.
6. Design and Testing:

    a) MSS SP-72 for flanged ends.
    b) MSS SP-110 for threaded and grooved ends.

D. Butterfly Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:

    a) Body: Lug ends suitable for connecting to ASME B16.5 flanges, or grooved ends.

        1) Cast iron according to ASTM A126.
        2) Ductile iron according to ASTM A536.
        3) Cast steel according to ASTM A216.

    b) Disc:

1) Aluminum bronze.
2) Stainless steel.
3) One-piece nylon coated ductile iron disc. Nylon coated discs are not allowed for open loop condenser water systems.

c) Stem: 416 Stainless steel. Include extension for insulation.
d) Replaceable PTFE or EPDM seats and seals.

3. Rangeability: Minimum 20:1.
4. Leakage: Minimum ANSI Class IV, per ANSI/FCI 70-2.
5. Design and Testing: MSS SP-67 for Class 150 and MSS SP-68 for pressure classes above 150.

E. Manufacturers:

1. Belimo.
2. Bray.
3. Danfoss.
4. Fisher Controls.
5. Griswold Controls.
6. Honeywell.
7. Johnson Controls, Inc.
8. Kele.
9. Schneider Electric.
10. Siemens.
11. Victaulic (Tour & Andersson).

F. At the contractor’s discretion, control valves and balancing valves may be combined into a single device. Submit pricing deduct as an alternate to the base bid.

1. Manufacturers:

a) Victaulic, TBV-TC/TCM Series.

G. Pressure Independent Control Valves (PICV):

1. Sizing:

a) Size valve and cartridge based on design flow rate through the circuit it serves. Choose the smallest valve rated by the manufacturer capable of delivering the design flow rate unless otherwise noted.

2. Construction:

a) Factory fabricated, Integrated valve body that incorporates an adjustable flow coefficient (Cv) chamber and separate pressure regulating chamber to maintain a constant differential pressure across the valve.
b) Field-adjustable: Capable of modifying the valve flow characteristics without removing the valve from the piping system.

c) Valve shall have a minimum of two integral ports factory installed capable of being used to measure pressure or temperature. If valve does not have these ports, contractor shall provide test ports on each side of valve for field verification.

d) 2 Inch and Smaller:

    1) Forged brass body conforming to ASTM B283.

e) 2-1/2 Inch and Larger:

    1) Ductile iron body conforming to ASTM A536.
    2) Cast carbon body conforming to ASTM A216.
    3) Stainless steel body conforming to ASTM A351.

f) Flow Regulator: Stainless steel.

g) Stem: Brass or stainless steel, blowout proof. Include extension for insulation.

h) Replaceable PTFE seats and EPDM O-ring or PTFE packing seals.

i) Characterizing Disc:

    1) Ball Type: Full port with characterized insert comprised of the following material:

        a) Stainless steel.
        b) Chrome-plated.
        c) Nickel-plated.

    2) Plug Type: Brass, TEFZEL, or stainless steel characterizing disc.

3. Electronic Actuator:

    a) Direct mounted, self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force.
    b) Supplied from the same manufacturer as the valve.
    c) Include visible position indicator.
    d) Overload Protection: Electronic overload or digital rotation-sensation circuitry.
    e) Fail-Safe Operation: Mechanical, spring-return mechanism or Capacitance return.
    f) Power Requirements: 24 VAC/DC motor; accepting a 0-10 Vdc or 4-20 mA signal.

4. PICVs shall be individually flow tested and factory verified with calibrated instruments to deviate not more than ± 5 percent through the selected operating pressure range. A calibrated performance tag shall be provided with each valve that verifies the flow in 10 degree rotation increments up to full rated flow.

5. Accuracy: PI control valve shall accurately control the flow from 0 to 100 percent rated flow within an operating pressure differential range of 5 to 50 psi across the valve.

6. Leakage: Minimum ANSI Class IV per ANSI/FCI 70-2. Valve shall be equipped with proper packing to ensure there will be no leakage at the valve stem.
7. Design and Testing:
    a) MSS SP-72 for flanged ends.
    b) MSS SP-110 for threaded and grooved ends.
8. PI control valves shall be provided with electronic actuator driven by a 24VAC/DC motor from a 0-10Vdc or 4-20 mA signal.
9. Extended Warranty: Minimum of 5 years from date of shipment.
10. Manufacturers:
    a) Belimo.
    b) Bray.
    c) Danfoss.
    d) Flow Control Industries.
    e) Griswold Controls.
    f) Honeywell.
    g) Johnson Controls.
    h) Oventrop.
    i) Victaulic (Tour & Andersson).

H. Solenoid-Operated Control Valves:

1. Construction:
    a) Factory fabricated, heavy duty assembly.
    b) Body and Trim:
        1) Bronze
        2) Stainless steel.
    c) Replaceable PTFE seats and disc.
    d) Solenoid Enclosure: NEMA 250, Type 4.
2. Action:
    a) As indicated on the drawings.
    b) Manual override capable.
3. Operator: Spring return with normal position and power requirements as indicated on the drawings.
    a) Reference Valve Operators section below for additional requirements.

2.03 CONTROL DAMPERS

A. Dampers shall be factory fabricated and sized as shown on drawings and as specified.

B. Individual damper sections shall not be larger than 48 inches x 60 inches. Provide a minimum of one damper actuator per section.

C. Performance: Test in accordance with AMCA 500-D.

1. Pressure Drop: Unless otherwise scheduled or indicated on the Drawings, size control dampers as follows:

a) Modulating Dampers: Provide dampers with linear flow characteristics. Size modulating dampers based on the smaller of the following.

1) Maximum velocity of 1,500 feet per minute.
2) Maximum Full-open air pressure drop of 0.1 inches W.C.

b) Two Position Dampers: Dampers shall be full duct size and selected to minimize pressure drop.

2. Leakage:

a) Motorized dampers for outdoor, exhaust and relief air and for shaft and stairway vents shall be Class I leakage and shall not exceed 4.0 CFM/square foot in full closed position at 1 inch W.G. pressure differential across damper.
b) Motorized dampers for other applications shall be Class II leakage.

D. Frames: Galvanized steel, extruded aluminum, or stainless steel, welded or riveted with corner reinforcement.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 20 gauge for round dampers.
3. For aluminum frames, use 1/8 inch thick material.
4. All damper frames shall have a flange for duct mounting.
5. Reference Part 3 Execution for application of the material type.

E. Blades: Galvanized steel, extruded aluminum, or stainless steel, maximum blade size 6 inches wide, 48 inches long, attached to minimum 1/2 inch shafts with set screws.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 16 gauge for round dampers.
3. For aluminum blades, use 1/8 inch thick material.
4. The blades shall be suitable for the air velocities to be encountered in the system.
5. Dampers longer than the maximum blade length shall be fabricated in sections.
6. Reference Part 3 Execution for application of the material type.

F. Blade Seals: Synthetic elastomeric inflatable or Neoprene, mechanically attached, field replaceable.

1. Installed along the top and bottom of the frame and on all mating surfaces.

G. Jamb Seals: Spring stainless steel.

1. Installed inside the frame sides.

H. Shaft Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze.
2. Graphite impregnated nylon sleeve with thrust washers at bearings.
3. Lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race.
4. Molded synthetic bearings.

I. Linkage Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze
2. Graphite impregnated nylon.

J. Maximum Pressure Differential: 6 inches wg.

K. Temperature Limits: -40 to 200 degrees F.

L. Manufacturers:

1. Greenheck.
2. CESCO.
3. Pottorff.
4. Nailor.
5. Ruskin.

M. Reference the Damper Schedule in Part 3 for basis of design damper model and material for the application.

2.04 OPERATORS

A. General:

1. Voltage: Voltage selection shall be as required to achieve the required torque for the application.

a) Reference Part 3 for Damper Operator Voltage Schedule.

2. Type: Motor operated, with or without gears. Motor type shall be continuous duty.
3. Construction:

a) For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.

b) For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.

c) For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

4. Field Adjustment:

a) Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.

b) Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

5. Two-Position Actuators: Single direction, spring return or reversing type. End-switches shall be integral to the actuator to determine actuator status.

6. Modulating Actuators:

a) Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.

b) Control Input Signal:

1) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.

2) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-Vdc or 2- to 10-Vdc and 4- to 20-mA signals.

3) Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.

c) Programmable Multi-Function:

1) Control Input, Position Feedback, and Running Time: Factory or field programmable.

2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.

3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

7. Position Feedback:

a) Where indicated on the controls drawings, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.

b) Where indicated on the controls drawings, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
c) Actuator shall contain position indicator and graduated scale indicating open and closed travel limits.

8. Integral Overload Protection:

a) Provide against overload throughout the entire operating range in both directions.
b) Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

9. Attachment:

a) Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to device without the need for connecting linkages.
b) Attach actuator to device drive shaft in a way that ensures maximum transfer of power and torque without slippage.

10. Temperature and Humidity:

a) Temperature: Suitable for operating temperature range encountered by application.
b) Humidity: Suitable for humidity range encountered by application, non-condensing.

11. Enclosure:

a) Suitable for ambient conditions encountered by application.
b) NEMA 4 for indoor wash-down or wet locations.
c) NEMA 4X, Belimo ZS-300, or equivalent; for outdoor applications.
d) Provide actuator enclosure with heater and control where required by application.

12. Stroke Time:

a) Coordinate with stroke time indicated on the control drawings.
b) Unless otherwise noted, select operating speed to be compatible with equipment and system operation.

B. Damper Operators:

1. Controls contractor shall size damper operator.
2. Sizing: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.

a) Provide sufficient number of operators to achieve unrestricted movement throughout damper range.

b) Provide one operator for maximum 20 sq ft damper section or maximum 7 in-lb/sq ft damper area.

3. Fail Positions:

a) Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection. Normal positions are indicated on the control drawings.

1) Return air damper, normally open.
2) Outside air damper, normally closed.
3) Exhaust/Relief air damper, normally closed.

b) Operator shall fail in place for all other applications not listed under spring return.

C. Valve Operators

1. Sizing: Select operator with sufficient torque capacity to operate the valve under all conditions and to guarantee tight shut-off of as specified against system pressure encountered.

a) Operators for Hydronic Control Valves: Capable of closing valve against system pump dead head.

2. Fail Positions:

a) Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection.

1) Pre-heat coil, normally open.
2) Other devices needing fail safe operation to account for freeze protection, power failure, overheating or moisture damage, reference control drawing points list for normal position.

b) Operator shall fail in place for all other applications not listed under spring return.

D. Manufacturers:

1. Damper Operators:

a) Belimo.
b) Honeywell.
c) Johnson Controls.
d) Schneider Electric (Invensys).
e) Siemens.

2. Valve Operators:

a) Belimo.
b) Bray.
c) Danfoss.

d) Fisher Controls.
e) Honeywell.
f) Johnson Controls.
g) Schneider Electric (Invensys).
h) Siemens.

2.05 FLOW MEASURING APPARATUS

A. Airflow Measuring Stations

1. Sensor quantity and spacing shall comply with the Equal-Area or Log-Tchebycheff method as defined in the ASHRAE Handbook of Fundamentals.
2. Element Construction: Non-corrosive material such as stainless steel, aluminum, or cadmium-plated.
3. Stations and insertion elements utilizing thermal dispersion technology shall utilize hermetically sealed thermistors for each sensor and shall be factory calibrated to NIST traceable standards.
4. Stations and insertion elements using velocity pressure shall be tested and certified in accordance with AMCA 611.
5. Air Inlet Measuring Stations:

a) Intended for location within an air inlet to equipment, such as a hood or louver.
b) Elements:

1) Element constructed of 316 stainless steel, factory mounted in a circular puck constructed of 14 gauge galvanized steel. Housing shall meet NEMA 1.
2) Element shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.
3) Element shall not be affected by the presence of moisture, dirt, or debris in the airstream and shall be unaffected by gusting wind.
4) Density corrected for ambient temperature variances and atmospheric pressure due to altitude.

c) Range: Minimum 100 to 2,400 fpm.
d) Accuracy: Plus/minus 5.0 percent of reading within the calibrated airflow range.
e) Manufacturers:

1) Air Monitor Corporation.
2) Approved equal.

6. Fan Inlet Air Flow Measuring Stations:

a) Located in the fan cone inlet with a minimum of two sensing elements.
b) Traverse Type Elements:

1) The elements shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.

c) Surface Mount Probes:

1) Thermal Dispersion Type: Two surface mounted thermal dispersion probes mounted on opposite ends of the fan cone shall monitor the airflow.

d) Range: Minimum 100 to 10,000 fpm.
e) Accuracy: Plus/minus 3.0 percent of the measured airflow range.
f) Manufacturers:

1) Air Monitor Corporation.
2) Ebtron.
3) Johnson Controls.
4) Ruskin.
5) Sensocon.

7. Duct Air Flow Measuring Stations

a) Located in a configuration and size equal to that of the duct it is installed.
b) The airflow traverse probe shall not induce a measurable pressure drop, nor amplify the sound level within the duct by its presence in the airstream.
c) Flow Straightener: Provide flow straightener as required by manufacturer of construction as needed to meet the application.
d) Range: Minimum 400 to 4,000 fpm.
e) Accuracy: Plus/minus 2.0 percent of the measured airflow.
f) Manufacturers:

1) Air Monitor Corporation.
2) Ebtron.
3) Johnson Controls.
4) Ruskin.
5) Sensocon.

8. Signal Processor:

a) Microprocessor-based, field programmable, capable of local display of the measured airflow rate.
b) Factory calibrated to NIST traceable standards.
c) Accuracy: 0.1 percent of full scale, including linearity, hysteresis, dead band, and repeatability.
d) Output: 0 to 10 Vdc or 4-20 mA scaled output signal for remote monitoring.

B. Water Flow Meter: Provide Water Flow Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”.

C. BTU Meter: Provide BTU Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

D. Gas Flow Meter: Furnish gas flow meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

2.06 HUMIDISTATS

A. Room Humidistats:

1. Performance Characteristics:

a) Throttling range: Adjustable 2 percent relative humidity.
b) Accuracy: Plus/minus 3 percent over the operating range.

1) Accuracy shall include temperature effects.

c) Operating range: 20 to 80 percent.
d) Drift: Less than 1 percent per year.

2. Construction:

a) Wall-mounted enclosure: Plastic, NEMA 250, Type 1.
b) Cover: Set point indication.

3. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal..

B. Limit Duct Humidistat:

1. Insertion, two position switch type.
2. Performance Characteristics:

a) Throttling range: Adjustable 2 percent relative humidity.
b) Accuracy: Plus/minus 5 percent over the operating range.

1) Accuracy shall include temperature effects.

c) Operating range:

1) High Limit Type: Minimum 50 to 95 percent.

d) Drift: Less than 1 percent per year.

3. Construction:

a) Enclosure: Metal, NEMA 250, Type 1.

2.07 INPUT/OUTPUT SENSORS AND TRANSMITTERS

A. General:

1. Performance Requirements:

a) Device must be compatible with project DDC controllers.
b) Elements used shall be general-purpose type.

c) Provide transmitters or transducers with sensors as required, with range suitable for the system encountered.

1) Transmitters and transducers shall have offset and span adjustments.
2) Shock and vibration shall not harm the transmitter or transducer.
3) Transmitters and transducers shall have a zeroing capability of readjusting the transmitter zero.

d) Accuracy requirements shall include the combined effects of linearity, hysteresis, repeatability, and the transmitter.

2. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal.
3. Input Power: Low voltage, nominal 24 Vdc.

B. Temperature Sensors:

1. General: Temperature sensing elements shall have characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy. Sensor shall be UL 873 listed for temperature equipment.
2. Performance Requirements:

a) Thermistor:

1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
2) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.
3) Resolution: Plus/minus 0.2 degrees F minimum.
4) Heat Dissipation Constant: 2.7 mW per degree C.
5) Drift: 0.04 degree F after 10 years within temperature range.

b) RTD:

1) Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
2) Accuracy (All): Plus/minus 1 degree F minimum, unless otherwise noted below.

a) Room Sensor Accuracy: Plus/minus 0.5 degrees F minimum.
b) Chilled Water Accuracy: Plus/minus 0.5 degrees F minimum.
c) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.

3) Resolution: Plus/minus 0.2 degree F.
4) Drift: 0.04 degrees F after 10 years within temperature range.

c) Sensing Range:

1) Provide limited range sensors if required to sense the range expected for a respective point.

d) Wire Resistance:

1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.

3. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
4. Room Temperature Sensors:

a) Construct for surface or wall box, or enclosure with insulated backing suitable for exterior wall mounting.
b) Button Sensor for High Finish Spaces: Where noted on the drawings or scheduled, provide cable type, button probe sensor designed for flush mounting in wall or ceiling with the following features:

1) 6 inch leads.
2) 1/2 inch plastic spacer with locking nut.
3) Finish as specified on the drawings. If not specified, provide Plastic, field paintable finish.

c) Provide the following features:

1) Setpoint reset slide switch, dial wheel, or push-button interface with an adjustable temperature range.
2) Momentary override request push button for activation of after-hours operation.
3) Integral digital display with the following:

a) Indication of space temperature.
b) Setpoint adjustment to accommodate room setpoint.
c) Manual occupancy override and indication of occupancy status.

5. Temperature Averaging Elements:

a) Use on duct sensors for ductwork 10 sq ft or larger.
b) Use averaging elements where prone to stratification with sensor length range between 16-22 ft.
c) Provide for all mixed air and heating coil discharge sensors regardless of duct size.

6. Insertion Elements:

a) Use in ducts not affected by temperature stratification or smaller than 10 sq ft.
b) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches for pipe sizes greater than 4 inches.
c) Immersion Well Housing: 1/2 inch NPT brass or stainless steel. Stainless steel required for piping 6 inch and larger.

C. Humidity Sensors:

1. Elements: Accurate within 3 percent full range with linear output.

a) Accuracy shall include temperature effects.

2. Resolution: Plus/minus 1 percent.
3. Drift: Less than 1 percent full scale per year.
4. Sensing Range: 0 to 100 percent relative humidity.
5. Room Sensors: Provide housing with integral sensor. Housing shall be plastic, NEMA 250, Type 1. Provide with insulated backing suitable for exterior wall mounting.

a. Cover: Provide display indicating sensed humidity value.

6. Duct Sensors: Insertion type probe with mounting plate. Housing shall be metal, NEMA 250, Type 1.
7. Outside Air Sensors: With element guard and mounting plate.

D. Pressure Transmitters:

1. Duct Static Pressure:

a. Type: Unidirectional, fixed range.
a) Performance Characteristics:

1) Accuracy: Plus/minus one percent of full scale.
2) Thermal Effects: Temperature compensated over a minimum 40 to 120 F range. Zero and span shift of plus/minus 0.06 percent or less of full scale per degree F.
3) Sensing Range: Select sensor so that the high end of the nominal sensor range is not less than 150 percent and not more than 300 percent of maximum expected input.
4) Long Term Thermal Stability: Plus/minus one percent full scale per year.

b) Construction:

1) Insertion or traverse type sensor suitable for use in flat oval, rectangular, and round duct configurations.
2) Insertion length selected as appropriate for duct size.
3) Traverse sensors shall have at least one pickup point every 6 inches.
4) Element: Variable capacitance sensing technology.

5) Housing: Fire retardant glass-filled polyester, brass, stainless steel, or aluminum.

2. Hydronic Pressure:

a. Type: Unidirectional, fixed range.

a) General Sensor Performance Characteristics:

1) Accuracy: Plus/minus 1.0 percent of full scale.
2) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F
3) Long Term Thermal Stability: Plus/minus 0.5 percent full scale per year.
4) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.

b) Performance Characteristics for Chiller/Boiler Equipment Differential Pressure:

1) Application: Variable-Primary Flow Systems.
2) Accuracy: Plus/minus 0.05 percent of full scale.
3) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F.
4) Long Term Thermal Stability: Plus/minus 0.125 percent full scale per year for minimum 5 years.
5) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.
6) Manufacturers:

a) Rosemount, 3051S
b) Approved equal.

c) Construction:

1) Suitable for the media temperature and pressure.
2) Chiller/Boiler differential sensor shall have push button zero and span adjustments. No internal mechanical linkages shall be used in the transmitter.
3) Element: Diaphragm type, stainless steel.
4) Housing: Fire retardant glass-filled polyester, stainless steel, or aluminum.

3. Gas Pressure:

a) Type: Uni-directional, fixed range.
b) Performance Characteristics:

1) Accuracy: 0.35% full scale.
2) Operating Temperature Range: -40 to 260 F.

3) Long Term Drift: Plus/minus 0.2% full scale per year.
4) Sensor Output: 4-20 mA.
5) Range: Select sensor so that the scheduled pressure setpoint is near the midrange of the sensor pressure range.

c) Construction:

1) Suitable for the media temperature and pressure.
2) Sensor Element: 17-4 PH or 316L stainless steel.
3) Housing: Stainless steel with FKM, EPDM or all welded seals.

E. Equipment Operation Sensors:

1. Status Inputs for Airside Equipment:

a) Type: Fixed range differential pressure switch with adjustable setpoint.
b) Performance Characteristics:

1) Range: Not greater than two times the design fan static pressure.

c) Construction:

1) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
2) Provide Insertion tube for use in duct configurations. Insertion length selected as appropriate for duct size.
3) Contact Type: Single-pole, single-throw (SPST). Provide multiple poles or throw contacts to meet additional alarms required.

2. Status Inputs for Hydronic Equipment:

a) Differential Pressure Switch: Fixed range type with adjustable setpoint.

1) Range: Not greater than two times the design equipment differential pressure.
2) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
3) Contact Type: Single-pole, single-throw (SPST). Provide double-throw contacts to meet additional alarms required.

b) Flow Switch:

1) Thermal dispersion flow switch enclosed in insertion device, of material suitable for fluid encountered and magnetic setpoint coordinated with the desired flow rate.

a) Range: Sensitivity suitable for the maximum and minimum design flow rates of the system in which it is installed.

b) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered, with LED status indicators for visual switch indication.
c) Contact Type: Automatic reset upon regain of flow.

3. Status Inputs for Electric Motors:

a) Analog Current Transducer:

1) Type: Split core design, cable of being installed or removed without dismantling the primary bus cables.
2) Performance Characteristics:

a) Accuracy: Plus/minus 2 percent of selected range.
b) Range: Multi-range device, suitable for the amperage encountered with internal zero and span adjustment.
c) Analog output signal: Generate a proportional control signal relative to the amount of current through the primary bus cables.

3) Construction:

a) 24 V or Self-powered (passive).
b) Provide with integral command relay.
c) Device shall accept overcurrent up to twice its trip into range.
d) Enclosure: UL 94 approved thermoplastic, rated for V-0. No metal parts shall be exposed other than the terminals.

b) Binary Current Sensing Relay:

1) Type: Split core with current transformers, adjustable and set to 175 percent of rated motor current.
2) Self-powered (passive) with solid-state circuitry and a dry contact output.
3) Adjustable trip point.
4) Contact Type: Single-pole, double-throw (SPDT).
5) LED indicating the on or off status.
6) A conductor of the load shall be passed through the window of the device.
7) Device shall accept overcurrent up to twice its trip into range.

F. Carbon Monoxide Detectors:

1. Factory calibrated, single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F.

2. Provide individual indicators and contractors for each level, initially calibrated for 25 ppm and 200 ppm.
3. Maximum response time to 100 ppm CO calibration gas: Two minutes.
4. Accuracy: Plus/minus 5 ppm or plus/minus 5 percent of reading, whichever is lower.
5. Drift: Certified by manufacturer to drift no more than 5 percent per year.
6. Calibration: Certified by manufacturer to require calibration no more frequently than once per year.

G. Nitrogen Dioxide Sensors:

1. Single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F.
2. Provide individual indicators and contractors for each level, initially calibrated for 1 ppm and 3 ppm.
3. Accuracy: Plus/minus 5 percent of reading.

H. Carbon Dioxide Sensors:

1. General: Provide non-dispersive infrared (NDIR) CO2 sensors with integral transducers and linear output.

   a) Linear, CO2 Concentration Range Display: 0 to 2000 ppm.
   b) Full Scale Accuracy: Plus/minus 75 ppm at concentrations of both 600 and 1,000 ppm when measured at sea level at 77 degrees F.
   c) Maximum Response Time: 1 minute.
   d) Analog Output: 0-10 Vdc or 4-20 mA.
   e) Rated Ambient Conditions:

      1) Air Temperature: Range of 32 to 122 degrees F.
      2) Relative Humidity: Range of 0 to 95 percent (non-condensing).

2. Calibration Characteristics:

   a) Factory calibrated and certified by the manufacturer to require calibration not more frequently than once every 5 years.
   b) Automatically compensating algorithm for sensor drift due to sensor degradation.
   c) Sensor shall be temperature compensated throughout entire operating range.
   d) Maximum Drift: 2 percent per year.

3. Construction:

   a) Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
   b) Duct Mounting: Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.

c) Wall/Surface Mounting: Construct for surface or wall box or enclosure suitable for wall mounting.

2.08 OUTPUT CONTROL DEVICES

A. Control Relays:

1. Provide relay with contact rating, configuration, and coil voltage that is suitable for the application.
2. Provide NEMA 1 enclosure when relay is not installed in a local control panel.
3. Control relays shall be UL listed plug-in type with dust cover and LED “energized” indicator.
4. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus/minus 200 percent minimum from setpoint.

B. Fan Speed Controllers:

1. Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.

2.09 POWER SUPPLIES

A. Reference Division 23 Section “Direct Digital Controls for HVAC” for DC power supply requirements.

B. Control power transformers shall meet NEMA/ANSI standards.

C. Control power transformers shall be UL listed for Class 2 current-limited service or provided with over-current protection on both primary and secondary circuits for Class 2 current-limited service.

D. Connected load on the transformer shall not exceed 80 percent of the transformer’s rated capacity.

E. The core and windings shall be completely encased in a UL approved thermoplastic. No metal parts shall be exposed other than the terminals.

F. Performance Characteristics:

1. Accuracy: Plus/minus 1 percent at 5.0 A full scale output.

G. Provide a disconnect switch for each transformer.

2.010 THERMOSTATS

A. General:

1. Programmable, with the following features:

a) LCD or LED display screen.
b) Button our touch-screen Interface.
c) 7-day programmable scheduling.
d) Temperature information display.
e) Setpoint display and adjust.
f) Override.
g) Lockout.

2. Non-programmable with the following features:

a) LCD or LED display screen.
b) Button our touch-screen Interface:
c) Temperature information display.
d) Setpoint display and adjust.
e) Operation mode display and adjust.
f) Fan switch setting (Off/Auto/Low/Med/High), configured with the fan system it serves.
g) Override.
h) Remote temperature sensor interface terminal.
i) Lockout.

3. Performance Requirements:

a) Accuracy: Plus/minus 1.0 degree F minimum.
b) Resolution: Plus/minus 0.2 degrees F.
c) Range:

1) Operating Temperature: 32 degrees F to 122 degrees F minimum.
2) Operating Humidity: 0 percent to 95 percent relative humidity, non-condensing.
3) Setpoint Control:

a) Cooling: 54 degrees to 100 degrees F.
b) Heating: 40 degrees to 90 degrees F.

d) Multi-stage as required to match unit cooling and heating stages scheduled on the drawings.

B. Electric Room Thermostats:

1. Type: 24 volts, two position switch, programmable with setback/setup temperature control.
2. Covers: Locking with set point adjustment and indication.
3. Setpoint functional range: 45 degrees F to 90 degrees F.

C. Line Voltage Thermostats:

1. Integral manual On/Off/Auto selector switch, single or two pole as required.
2. Dead band: Maximum 2 degrees F.
3. Covers: Locking with set point adjustment and indication.
4. Setpoint functional range: 45 degrees F to 90 degrees F.

5. Rating: Motor load.

D. Room Thermostat Accessories:

1. Thermostat Covers: Plastic.
2. Insulating Bases: For thermostats located on exterior walls.
3. Adjusting Key: As required for device.
4. Aspirating Boxes: Where indicated for thermostats requiring flush installation.
5. Integrated sensors: At the contractor's option, the following sensors may be provided with the thermostat in a single device. Refer to the drawings where additional sensors are required. Refer to "Input/Output Sensors" section of this specification for language governing performance of the integrated sensors.

    a) Humidity sensor.
    b) Carbon dioxide sensor.

E. Immersion Thermostat:

1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.

F. Airstream Thermostat:

1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
2. Averaging service remote bulb element: minimum 20 feet or length as required to fit duct.

G. Electric Low Limit Thermostat:

1. Snap acting, single pole, single throw, manual or automatic reset switch as indicated on the drawings that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,

    a) Provide double-throw contacts (one for direct equipment control, one for BAS system notification) where additional alarms are scheduled.

2. Bulb length: Minimum 1 foot for every 1 square foot of coil cross sectional area.
3. Provide one thermostat for every 20 sq ft of coil surface.
4. Setpoint shall be adjustable.

H. Electric High Limit Thermostat:

1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above setpoint,

2. Bulb length: Minimum 1 foot for every 1 square foot of coil cross sectional area.
3. Provide one thermostat for every 20 sq ft of coil surface.
4. Setpoint shall be adjustable.

I. Fire Thermostats:

1. UL labeled, factory set in accordance with NFPA 90A.
2. Normally closed contacts, manual reset.
3. Fixed or adjustable settings to operate at not less than 75 degrees F above normal maximum operating temperature.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.02 INSTALLATION

A. Cooperate with other contractors performing work on this project as necessary to achieve a complete and coordinated installation. Each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others work.

B. General Workmanship:

1. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.
2. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
3. Install all equipment in readily accessible locations.
4. All installations shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
5. Install all products in accordance with manufacturer's instructions.

C. Sensors:

1. Mount sensors rigidly and adequately for the environment within which the sensor operates.
2. Provide thermistor type temperature sensors for temperature ranges between minus 30 degrees F to 230 degrees F. Provide RTD type temperature sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing. Coordinate installation of room/space sensors with architect and other trades to ensure a neat and orderly installation.
4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
5. Sensors used in mixing plenums and hot and cold decks shall be of averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
6. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
7. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 feet downstream.
8. Install temperature, humidity, and smoke detectors for both supply air and return air applications a minimum of 10’-0” downstream or upstream of the air handling unit and prior to any branch duct takeoffs.
9. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
10. Install outdoor air temperature sensors on north wall, complete with sun shield where shown on the plans. If not shown, locate sensors in an accessible location, a minimum of 15 feet away from exhaust or relief air locations.
11. Differential air static pressure.

    a) Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
    b) Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor or the plenum.
    c) Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building. Pipe the high-pressure port to a location suitable to sense common building pressure or as indicated on the drawings.

1) Panel mount the transducer adjacent to its associated building automation system controller. Provide an independent manometer gauge next to transducer for calibration.

d) The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

e) All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

f) All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

12. Adjust flow switch to meet sensitivity required to ensure minimum flow through the equipment.
13. Verify location and mounting height of thermostats, humidistats, and exposed control sensors with plans and room details before installation. Align with adjacent lighting switches and humidistats.

    a) Install devices to meet ADA requirements unless otherwise noted on the plans.

14. Mount freeze protection thermostats using flanges and element holders.

    a) Install thermostat completely across the surface the thermostat serves.

15. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
16. Provide separable sockets for liquids and flanges for air bulb elements.
17. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
18. Install shutoff valves in the high and low pressure reference lines connecting to hydronic pressure sensors and switches. Install a shunt valve across the high and low reference pressure ports for servicing. Valves may be ordered as an integral option with the sensor.

D. Control Valves:

1. Do not install brass valves in open-loop systems.
2. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
3. Install flanges or unions to allow valve removal and installation.
4. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
5. Valve Orientation:

a) Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
b) Install valves in a position to allow full stem movement.
c) Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

6. Provide valves with position indicators where sequenced with other controls.
7. Tag valves in accordance with Division 23 Section, "Identification for HVAC Piping and Equipment."
8. Install a pressure/temperature port on each side of pressure independent control valves (PICVs) which are not factory provided with integral ports.

E. Control Dampers:

1. Install dampers with extruded aluminum or stainless steel frames and blades in corrosive environments and areas with high humidity.
2. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
3. Clearance:

a) Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
b) Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

4. Service Access:

a) Dampers and actuators shall be accessible for visual inspection and service.
b) Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Division 23 Section, “Air Duct Accessories.”.

5. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting.
6. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
7. Provide mixing dampers of parallel blade construction arranged to mix streams. Where shown on the drawings, provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.
8. Provide isolation (two position) dampers of parallel blade construction.

9. Provide opposed blade damper configuration for all other applications.
10. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
11. After installation of low-leakage dampers and seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

F. Operators:

1. Mount and link control damper actuators according to manufacturer’s instructions.

    a) To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.
    b) Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
    c) Provide all mounting hardware and linkages for actuator installation.

2. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degree available for tightening the damper seals.
3. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer.

G. Control Panels:

1. Install control panels where shown on the drawings and where required to house controllers for the controlled systems and equipment.
2. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
3. Coordinate 120V power requirements with Division 26 to panels used for the building automation system and transformers for low voltage power to controllers.

H. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

I. Provide an insulation standoff on control devices, cables, and other items that do not require flush mounting to ductwork, piping, or equipment.

3.03 MAINTENANCE

A. Refer to Division 01 closeout requirements for additional requirements relating to maintenance service.

B. Provide service and maintenance of control system for one year from Date of Substantial Completion.

C. Provide complete service of controls systems, including call backs, and submit written report of each service call.

3.04 STARTUP AND DEMONSTRATION

A. Control Dampers and Valves:

1. Stroke and adjust control valves and dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
2. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
3. For control valves and dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
4. Verify that all two-position dampers and valves operate properly and that the normal positions are correct.
5. Verify that all modulating dampers and valves are functional, that the start and span are correct, that direction and normal positions are correct, and that they achieve proper closure.

B. PI Control Valves:

1. Field verify installation and operating differential pressure range of all PI control valves.
2. Verify total system flow to be within plus/minus 10 percent of system design.
3. Individual field adjustments for the PI control valve assembly shall be performed using the PI control valve manufacturer’s documented procedures.

3.05 DAMPER SCHEDULE

SERVICE	RUSKIN MODEL	MATERIAL
Outside, Exhaust and Relief Air Control, Stairway and Shaft Vents	CD-50	Aluminum
Fire/Smoke Damper for Smoke Control	FSD-60	Galvanized Steel
All Other	CD-356	Galvanized Steel

3.06 DAMPER OPERATOR VOLTAGE SCHEDULE

SERVICE	VOLTAGE
Interlocked with HVAC fans	120V
Multi-section dampers	120V
Large dampers (> 60 inches in any dimension)	120V
All other operators control wiring	24V

1. Note: Coordinate with Division 26 if 120V power is required for operator to achieve appropriate torque requirements for damper actuation.

3.07 CONTROL VALVE SCHEDULES

A. Allowable Valve Type and Size by Control Application:

VALVE	CONTROL APPLICATION	
TYPE	MODULATING	TWO-POSITION
Globe	≤ 4 IN	≤ 2 IN
Characterized Ball	≤ 4 IN	≤ 4 IN
Butterfly	> 4 IN	≥ 2-1/2 IN

B. Allowable Valve Body Material by Service Application:

VALVE BODY	SERVICE APPLICATION	
MATERIAL	CLOSED LOOP	OPEN LOOP
Bronze	Allowed	Allowed
Brass	Allowed	Not Allowed
Iron	Allowed	Allowed

C. Allowable End Connection by System Material:

1. Copper Tube:

   a) 2-1/2 Inch and smaller: Threaded ends.

2. Steel Pipe:

   a) 2 Inch and Smaller: Threaded.
   b) 2-1/2 Inch and Larger:

      1) Flanged.
      2) Grooved ends for water systems.

D. Allowable End Connection by Size Schedule:

VALVE	END CONNECTION TYPE		
TYPE	THREADED	FLANGED	GROOVED
Globe	≤ 2-1/2 IN	≤ 4 IN	N/A
Characterized Ball	≤ 2-1/2 IN	≤ 3 IN	N/A
Butterfly	N/A	≥ 2-1/2 IN	≥ 2-1/2 IN

END OF SECTION

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PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. Extent of vehicle emission monitoring systems work required by this Section is indicated on drawings and by requirements of this Section.

B. Control sequences are specified in this section or on the drawings

C. Refer to Division 26 Sections for the following work; not work of this Section.

1. Power supply conduit and wiring for power source to power connection of the control panel.

D. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections.

1. Control wiring between field-installed controls, indicating devices, and unit control panels.

1.02 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vehicle emission monitoring equipment, of types and sizes required, whose products have been in satisfactory use for a minimum of three years. Manufacturer shall submit a list of 12 similar projects.

B. Codes and Standards:

1. UL Compliance: Comply with UL Safety Standard for Vehicle Emission Systems.
2. NEMA Compliance: Comply with NEMA standards pertaining to enclosures for vehicle emission control systems
3. NFPA Compliance: Comply with NFPA 70 "National Electric Code" where applicable for electric equipment, devices and wiring.
4. ISO Compliance: Equipment shall be manufactured within an ISO 9001-2000 production environment.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for the vehicle emission monitoring system furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.

B. Shop Drawings: Submit shop drawings for the vehicle emission monitoring system, containing the following information:

1. Schematic flow diagram of system showing control panel and transmitting device(s).
2. Label each control device with setting or adjustable range of control.
3. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
4. Provide details of faces of control panels, including controls, instruments, and labeling.
5. Provide sequence of operation including alarm points and functions.

C. Maintenance Data: Submit maintenance instructions and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide vehicle emission monitoring systems of one of the following:

1. Airtest Technologies, Inc.
2. American Gas Safety.
3. Armstrong Monitoring.
4. Brasch Manufacturing Company.
5. Critical Environmental Technologies.
6. DSP – Monoxivent.
7. Sentech Corporation.
8. Specified Controls.
9. Tox Alert.
10. Vulcain Alarm, Inc. (a Division of Honeywell Analytics).

2.02 VEHICLE EMISSION MONITORING SYSTEM

A. General: Provide complete vehicle emission monitoring system as specified, consisting of control panel, transformer, and transmitting devices as required for a complete installation. Except as otherwise indicated, provide manufacturer’s standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer.

B. System Requirements: Vehicle emission monitoring system shall meet the following general requirements:

1. System shall be capable of detecting presence of CO and NO2 vehicle emissions at concentration levels as indicated. Manufacturer shall coordinate with the Contractor the specific requirements for this installation.
2. System shall be capable of indicating, alarming, and energizing ventilation equipment. The system shall also be capable of communicating with the building automation system specified in Division 23 Section “Direct Digital Control for HVAC” through an RS-232 or RS-485 port.
3. System installation shall consider monitoring sensing locations for early warning indication to prevent excessive emission levels without alarm.

C. Control Panel and Equipment: Provide control panel with suitable brackets for wall mounting, for each vehicle emission monitoring system. Install panel at location shown on the drawings.

1. Fabricate panels of galvanized steel, painted steel, or extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock.
2. Controller: Vehicle emission control panel shall be capable of communicating digitally with networked transmitters and relay modules. Provide sufficient communication buses to accommodate the number of addressable transmitters indicated.
3. Provide a single power supply, 17-27 Vac or 24-38 Vdc to power the entire vehicle emission monitoring network.
4. The control panel shall manage internal DPDT relays at fully programmable alarm levels and be capable of activating multiple relay modules. Relay rating shall be not less than 5 A, 30 Vdc or 250 Vac resistive load.
5. The control panel shall include a self-test function for all programmed outputs and a real time clock to enable operation of the outputs for a specific timeframe.
6. The control panel shall allow for output operation on alarms set at a maximum, minimum, or average value of a specific group of transmitters. This shall also allow alarm activation when a specific number or percentage of transmitters reaches their respective alarm levels.
7. The control panel shall indicate the exact concentration of gas, the gas detected, and the location of the sensor on a graphic LCD display. The LCD shall have color-coded LED for each alarm point with Green-Normal, Red-Alarm, and Yellow-Failure.
8. The control panel shall provide a minimum of two low--high alarm levels for each gas detected.
9. The control panel shall provide an audible alarm of minimum 65 dBA at three feet which may be activated at any programmable concentration level.
10. The control panel shall be factory programmed and field adjustable by integral keypad with program stored on Flash memory card.
11. The control panel shall be capable of local activation of ventilation equipment through programmable time-delay relays.

12. The control panel shall be capable of operation between zero and 120 degree F.
13. Provide a remote annunciator panel where indicated.
14. Provide BACnet communication capability over twisted-pair Ethernet (10BaseT) wires.

D. Vehicle emission transmitters: Vehicle emission transmitter(s) shall be provided for monitoring vehicle emission levels.

1. Transmitters shall be powered by the control panel single source power supply.
2. Transmitters shall be fully addressable and capable of communicating digitally through an RS-485 port.
3. Transmitters shall be capable of remote sensing up to a maximum of 300 feet.
4. Transmitters sensing cell shall automatically compensate for variations in relative humidity and temperature to maintain accuracy.
5. Each transmitter shall include an LED or digital display of gas concentration levels.
6. Transmitters shall be capable of operation at relative humidity levels of 5-90% and temperatures of zero to 100 degrees F.
7. Transmitter CO programmable alarm set points shall be 25 PPM (low first warning) and 200 PPM (high alarm warning).
8. Transmitter NO2 programmable alarm set points shall be 1 PPM (low first warning) and 3 PPM (high alarm warning).
9. Transmitters shall be capable of sending (through the control panel) analog 4-20mA signal to the BMS/DDC system.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which vehicle emission monitoring systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF VEHICLE EMISSION MONITORING SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications. Mount control panel at location indicated on the drawings at convenient height for user interface.

B. Communication Wiring: Transmitters shall be installed in daisy chain with end of line resistor on last transmitter.

C. Transmitter Location(s): Install vehicle emission transmitters at heights and locations indicated on the drawings. If location or height is not indicated, comply with the vehicle emission monitoring system manufacturer’s installation instructions.

3.03 ADJUSTING AND CLEANING

A. Start-Up: Start-up, test, and adjust vehicle emission monitoring system in presence of manufacturer’s authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer’s touch-up paint. Replace sensor filters, if contaminated during installation work.

C. Final Adjustment: After completion of installation, adjust vehicle emission monitoring system to meet system requirements.

D. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of vehicle emission monitoring system.

3.04 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of four hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

3.05 SEQUENCE OF OPERATION

A. Ventilation System Activation:

1. When CO concentration exceeds 25 PPM, activate the ventilation fans and open ventilation dampers to maintain concentration below the programmable first warning level of 25 PPM.
2. When NO2 concentration exceeds 1 PPM, activate the ventilation fans and open ventilation dampers to maintain concentration below the programmable first warning level of 1 PPM.

B. Alarm Activation:

1. Activate audible and visual alarms if CO concentration reaches 200 PPM.
2. Activate audible and visual alarms if NO2 concentration reaches 3 PPM.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. System Description.

B. Operator Interface.

C. Controllers.

D. Electrical Control Power Wiring and Low Voltage Wiring.

E. Local Area Network.

F. System Software.

G. Controller Software.

1.02 REFERENCE STANDARDS

A. ANSI/CEA 709.1.D - Control Network Protocol Specification; 2014.

B. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; most current edition.

C. IEEE C37.90.1 – IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, most current edition.

D. IEEE C62.41.2 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits, most current edition.

E. ISO 7498 – Information Processing Systems – Open System Interconnection – Basis Reference Model, International Standards Organization, most current edition.

F. NEMA – National Electrical Manufacturers Association.

G. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.04 DEFINITIONS

A. ASC: Application Specific Controller. Examples include controllers for specific applications (e.g., FCU, VAV box, etc.) that can be configured through any network services software.

A. ATU: Air Terminal Unit (e.g., VAV boxes, fan-powered boxes, fan coil units).

B. BAS: Building Automation System.

C. BTL: BACnet Testing Laboratories. Third party independent testing and listing program for devices which have been tested according to ASHRAE Standard 135.

D. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operations

E. DDC: Direct Digital Control.

F. EMT: Electrical Metallic Tubing

G. High voltage: 50 volts or higher.

H. IP: Internet Protocol.

I. LAN: Local Area Network.

J. VLAN: Virtual Local Area Network.

K. Low voltage: Below 50 volts.

A. NiCS: Niagara Compatibility Statement license.

L. OSI: Open System Interconnection

M. PC: Personal Computer.

N. PICS: Protocol Implementation Conformance Statement.

O. Point: Point is a generic term used to describe a single item of information in a BAS. Points may be further described as input, output, digital, binary, discrete, analog, modulating, internal, external, virtual or global. Each unique point used by digital controllers, or in a BAS, is typically identified by an address.

1.05 CONTRACTOR RESPONSIBILITIES

A. Reference the following sections for additional contractor responsibilities and coordination:

1. Division 23 Section “Electrical Coordination for Mechanical Equipment.”
2. Division 23 Section “Commissioning for HVAC.”
3. Division 23 Section “Instrumentation and Control Devices for HVAC.”

B. Reference Part 3 for additional electrical contractor responsibilities for BAS controls.

1.06 SUBMITTALS

A. Refer to Division 01 and Division 23 Section “General Mechanical Requirements” for submittal procedures.

B. General:

1. The drawings and specifications are not intended to show all details. The BAS contractor shall secure satisfactory information before submitting the proposal and include in the proposal a sum sufficient to cover all items of labor and material required for the complete installation for the devices and system described.
1. Inform Engineer in writing of any deviation in the exhibits submitted from the requirements of the drawings, specifications, and sequences of operations.

C. Product Data:

1. Submit manufacturer technical data for each system component and software module required for a complete installation.
2. Indicate dimensions, weights, and enclosure construction for all BAS distributed controllers.
2. Submit technical data on all new software supplied including description of functions performed by software and location within the system where software shall reside. Include all software licensing agreements.
3. Submit the PICS for each BACnet device used in the BAS.
4. Submit the NiCS for each type of Niagara station in the BAS.

D. Power and Communication Wiring Transient Protection:

1. Submit catalog data sheets providing evidence that all BAS products offered by the manufacturer are tested and comply with IEEE C62.41.2.
2. Testing shall include power and communication trunk wiring.
3. Compliance with IEEE C62.41.2 shall imply conformance with IEEE C37.90.1based on the stated position of ANSI and IEEE.

E. Shop Drawings:

1. Submit a trunk cable schematic showing locations of all programmable control units, controllers, and workstations, with associated network wiring.

    a) Indicate equipment served by each controller on the diagram.
    b) Indicate switches, power requirements to each controller, and daisy chained controllers.

3. Submit detailed schematic control drawings for each controlled device and equipment.

    c) Reference all control components to manufacturer make and model number.
    d) Include all control and power wiring with termination point (controller and terminal number).
    e) Include clearly indicated and written sequences of operation referenced to specific control components (e.g., "shall modulate valve V-3").
    f) Include default position (e.g., N.O., N.C., etc.) for all components where applicable.
    g) Clearly differentiate between existing components and new components.

a. Include detailed wiring diagrams showing methods of connections to VFDs, motor starters, energy meters, and all other devices, and all other field wiring necessary for system installation.
b. The use of ”typicals” will be allowed where appropriate.

2. Submit detailed drawings for each individual BAS distributed controller.

    a) Include controller identification.
    b) Include components included in the controller.
    c) Include numbering of terminals and communications ports.
    d) List connected data points, including connected control unit and input device.
    e) Include type of cable connected to each terminal port.
    f) Identify specific field devices wired to each terminal including identification of each field device and application.
    g) Clearly differentiate between existing controllers and new controllers.
    h) Indicate source (electrical panel ID) of 120V power to each panel to which 120V power is connected.
    i) Indicate method of connecting controller to equipment supplied by others and to existing communications networks.
    j) Indicate device instance and network number.

3. Submit floor plans that indicate the following:

    a) Location of all new BAS distributed controllers and control panels.
    b) Routing of all new building level network communications wiring not located in mechanical and electrical rooms.
    c) Routing of wiring to controllers, sensors, and control points not located in mechanical and electrical rooms.

d) Location of building system connection to Owner’s campus wide data network.

4. Submit methods and materials used to integrate into existing networks.
5. All control drawings and schematics shall be generated using AutoCAD software or equivalent. All project drawings shall be supplied to the Owner in a format as desired by the Owner upon project completion.

4. Submit system identification nomenclature.

a) Nomenclature shall be consistent throughout the network and consistent with any existing networks that are integrated. If not defined, nomenclature shall be similar to the point names shown on the drawings.
b) Object name and ID number shall be unique within a control device.
c) Control device instance name and ID number shall be unique within the network.
d) Network number shall be unique for each unique electrical segment in the BAS.

6. Indicate system graphics indicating monitored systems, data (connected and calculated) and operator notations.

a) Submit example graphic visualizations and screenshots for the BAS. At a minimum, submit examples for major HVAC equipment components, including chillers, boilers, air handling units, fan coil units, heat pumps, fans, etc.
b) Font size and type shall be manufacturer standard.
c) Provide graphics demonstration package in a format as desired by the Owner.

7. Indicate description and sequence of operation of operating, user, and application software.

F. System Analytics Database: Submit a database interface plan to Owner.

1. Plan shall demonstrate the look of the BAS interface.
2. Include example graphics of proposed trending functionality and archive functionality.
3. Plan shall be approved by Owner to meet their intent for accessibility and user-friendliness.

G. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

H. Manufacturer’s qualification statement.

I. Installer’s qualification statement.

J. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.

1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittals data in final "Record Documents" form.
3. All additions or changes to the BAS during the course of construction shall be reflected upon the drawings and submitted to the Engineer before project close-out.

K. Testing and Commissioning Reports and Checklists: Submit completed versions of all reports and checklists, along with all trend logs, used to meet the requirements of Part 3, Startup and Demonstration.

L. Operation and Maintenance Data:

1. Include maintenance data and recommended spare parts list for digital control equipment and control components.
2. Include trouble-shooting maintenance guides.
3. Include interconnection wiring diagrams showing complete field installed systems with identified and numbered system components and devices.
4. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
5. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
6. Include a maintenance manual which contains the information listed above, product data, shop drawings, final software code for sequences of operation and maintenance data in accordance with requirements of Division 01.
7. Include logbook for documentation of software updates and patches applied BAS for the time period included in the software licensing agreement.
8. Provide names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

M. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner’s name and registered with manufacturer.

N. Maintenance Materials:

1. Refer to Division 01 for additional provisions.
2. Extra Stock Materials: Two printer cartridges and cartons of printer paper.

1.07 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

C. BACnet devices used in the BAS shall be BTL listed according to its device profile.

D. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

E. Installer Qualifications: Company specializing in performing the work of the type specified and with minimum documented experience as follows:

1. All personnel of the BAS Contractor shall have a minimum of three years of experience within their appropriate trades.
2. All subcontractors utilized by the BAS Contractor shall have a minimum of five years experience within their appropriate trades.

F. Additional BAS Contractor Requirements:

1. Personnel, Coverage and Response Capabilities: The BAS Contractor shall have a fully staffed office with service technicians and systems engineers within a 50 mile radius of the project location.
2. Parts Stocking: The BAS Contractor shall have an independently verifiable inventory of electronic service parts. This electronic service parts inventory must have a worth of at least $100,000 per year over the last five years.
3. Past Projects: The BAS Contractor shall have completed a minimum of twenty projects within the last five years which are at least equal in dollar value and comparable scope to this project. A list of similar projects, dollar volume, scope, contact name and contact number shall be provided by the BAS Contractor if asked for by the Owner.

1.08 WARRANTY

A. Refer to Division 01 for additional project warranty requirements.

B. Labor and materials for the BAS specified shall be warranted free from defects in workmanship and material for a period of 2 years after Substantial Completion and system acceptance.

C. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.

D. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. If the work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start data and period.

E. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner’s written authorization.

F. Provide five year manufacturer’s warranty for field programmable micro-processor based units.

G. Special warranty on instrumentation:

1. All instrumentation shall be covered by manufacturer's transferable one-year "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

1.09 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

B. Software provider shall provide software updates and patches to the BAS as part of the software licensing agreement as the updates and patches are released. If any security vulnerabilities are discovered by the provider, the provider shall notify the client within five business days.

C. Ownership of Proprietary Material: Project-specific software and documentation shall become Owner's property upon project completion. This includes, but is not limited to the following:

1. Graphics.
2. Record drawings.
3. Database.
4. Application programming code.
5. Documentation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Corporate Edition Products: The following manufacturers and product lines shall be manufacturer's most current vintage and of open protocol design. Corporate editions shall be based on manufacturer developed software.

1. Automated Logic, WebCtrl.
2. Delta Controls, enteliBUS.
3. Johnson Controls, Metasys.
4. Schneider Electric, EcoStruxure Building Operation.

B. The above list of manufacturers applies to operator workstation software, controller software, the custom application programming language, building controllers, custom application controllers, and application specific controllers. All other products specified under Division 23 Section "Instrumentation and Control Devices for HVAC" need not be manufactured by the above manufacturers.

2.02 SYSTEM DESCRIPTION

A. General:

1. The BAS shall consist of all necessary hardware and software to perform the control sequences of operation as called for in the Specifications and Drawings. Contractor shall install and commission all necessary devices to ensure a reliable and stable network.
2. System design is based on a distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
3. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
4. The BAS shall be capable of integrating multiple devices, sensors, and functions from multiple control vendors into a common front end, including equipment supervision and control, alarm management, energy management, and trend data collection.
5. The BAS shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASC's, and operator devices.
6. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

B. Local Area Network:

1. The BAS shall be set up as a physically separate network within the building.

C. Network Architecture: The BAS network architecture shall be based upon the OSI basic reference model in accordance with ISO 7498.

1. Application/Network Layer:
   a) BACnet protocol complying with ASHRAE Standard 135.
2. Physical/Data Link Layer:
   a) Hard-wired type:
      1) Ethernet according to ISO 8802-2 protocol.
      2) EIA-485 Twisted Cable Pair according to Master Slave/Token-Passing (MS/TP) protocol.
3. Communication between operator workstation(s) and building controller(s):
   a) Ethernet.
4. Communication between building controller(s) and application specific and custom application controllers:

a) MS/TP.
b) PTP.

D. Web Services Enabled Network:

1. The network shall be capable of being accessed remotely over the internet via a virtual link according to Internet Protocol.
2. System software shall be based on a client/server architecture, designed around the open standards of web technology. The BAS server shall be accessed using a web browser over the BAS network, Owner's LAN, and remotely over the Internet (through the Owner's LAN).
3. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming. Connection shall be browser agnostic.

E. Network Integration:

1. The BAS network shall be integrated with other automation networks controlled by the Owner. Coordinate with the Owner's information technology (IT) department for networks that shall be integrated.
2. Provide gateways or other integration devices across networks with different communication protocol to provide a single network visibility and interoperability at the operator workstation. Coordinate communication protocol with each automation system specified.
3. Interoperable networks shall be capable of sharing all point and point information across networks to a single BAS front end.
4. Interoperable networks shall be capable of automatically downloading application program changes.
5. For integrated networks that cannot automatically download application program changes, provide a link to the Controller Manual Download Schedule, as defined in the submittals section of Part 1 on the BAS front end summary page
6. Integrate the following networks:

   a) Boiler plant master firing controller.
   b) Chiller controller.
   c) Lighting control systems.
   d) Security systems.
   e) Life safety systems.
   f) Fire alarm control panels.
   g) Security managers.
   h) Vehicle emission controller.

F. Network Interoperability:

1. Provide communication between control units over local area network (LAN).
2. Communication services over the LAN shall result in operator interface and value passing that is transparent to the network architecture as follows:

a) Connection of an operator interface device to any one controller on the network shall allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the network.

b) All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the network. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform network value passing.

2.03 OPERATOR INTERFACE

A. General:

1. The Operator Interface shall provide overall BAS supervision and system software interface. Communications from the workstation shall be executed directly to and between the integration level building controllers and field level controllers.
2. The operator interface shall be capable of command entry, information and alarm management, database management, access of all system data, and be independent of hardware technology.

B. Hardware:

1. Desktop:

a) Computer(s) and display(s) to be provided by BAS controls manufacturer.

b) PC shall be general purpose and commercially available, with sufficient memory and processing capability to meet the requirements of the BAS.

1) Quantity: 1.

1) Minimum RAM: 4.0 gigabytes.

2) Minimum Processing Speed: Intel i3 Dual Core Microprocessor or better running at no less than 3.0 gigahertz.

3) Minimum Hard Drive Memory: 500 gigabytes.

2) Drives: 32X CD Rom/8X DVD drive.

4) Ports:

a) Minimum of 2 USB 2.0 or faster ports on front of tower.

b) Minimum of 2 free USB 2.0 or faster ports on rear of tower.

b. Monitor: Minimum 17 inch VGA or higher resolution, color graphic LCD or LED monitor with a compatible VGA or higher resolution card.

c) Location(s): As directed by the Owner.

d) Network Connection:

1) Suitable for network technology provided.
2) Ethernet interface card with minimum Speed: 10/100/1000.

e) Standard 101 key keyboard.

f) Standard mouse with track wheel.

2. System Printer:

a) Printer(s) to be provided by BAS controls manufacturer.
b) Quantity: 1.
c) Type: Business/office quality inkjet or laser jet equivalent printer.
d) Resolution: Up to 600 x 1200 dots per inch (dpi) black and up to 4800 x 1200 dpi color.
e) Minimum Print Speed: Minimum 18 ppm black and 10 ppm color.
f) Locations(s): As directed by the Owner.

3. Database Save/Restore/Back-Up:

a) Back-up copies of all Building Controller and ASC data as well as mass storage for trend logs shall be stored in the mass storage device designated by the Owner.

1.2 CONTROLLERS

C. Building Controllers

1. General:

a) Input Power Requirements: 24Vac.
b) Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
c) Provide sufficient memory to support controller's operating system, database, and programming requirements.
d) Share data between networked controllers.
e) Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
f) Utilize real-time clock for scheduling.
g) Continuously check processor status and memory circuits for abnormal operation.
h) Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
i) Communication with other network devices to be based on assigned protocol.

j) Monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

2. Communication:

   a) Perform routing when connected to a network of custom application and application specific controllers.
   b) Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

      1) Port shall be USB type.

3. Anticipated Environmental Ambient Conditions:

   a) Outdoors and/or in Wet Ambient Conditions:

      1) Mount within NEMA 4X waterproof enclosures.
      2) Rated for operation at 40 to 150 degrees F and 95 percent RH, non-condensing.

   b) Conditioned Space:

      1) Mount within NEMA 1 dustproof enclosures.
      2) Rated for operation at 32 to 120 degrees F.

4. Local Keypad and Display for each Controller:

   a) Use for interrogating and editing data.
   b) System security password prevents unauthorized use.
   c) If the manufacturer does not normally provide a keypad and display for the controller, provide software and interface cabling needed to use a portable operator terminal for the system.

5. Provisions for Serviceability:

   a) Diagnostic LEDs for power, communication, and processor.
   b) Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
7. Power and Noise Immunity:

   a) Maintain operation at 90 to 110 percent of nominal voltage rating.
   b) Perform orderly shutdown below 80 percent of nominal voltage.
   c) Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention.
   d) Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

8. Surge and Transient Protection:

a) Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
b) Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

D. Custom Application Controllers

1. General:

a) Input Power Requirements: 24Vac.
b) Provide sufficient memory to support controller's operating system, database, and programming requirements.
c) Share data between networked, microprocessor based controllers.
d) Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
e) Utilize real-time clock for scheduling.
f) Continuously check processor status and memory circuits for abnormal operation.
g) Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
h) Communication with other network devices to be based on assigned protocol.
i) Monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

2. Communication:

a) Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:

a) Outdoors and/or in Wet Ambient Conditions:

1) Mount within NEMA 4X waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F and 95 percent RH, non-condensing.

b) Conditioned Space:

1) Mount within NEMA 1 dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F.

4. Provisions for Serviceability:

a) Diagnostic LEDs for power, communication, and processor.
b) Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:
    a) Maintain operation at 90 to 110 percent of nominal voltage rating.
    b) Perform orderly shutdown below 80 percent of nominal voltage.
    c) Upon restoration of normal power, the Digital Panel shall automatically resume full operation without manual intervention.
    d) Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
7. Surge and Transient Protection:
    a) Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
    b) Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

E. Application Specific Controllers

1. General:
    a) Input Power Requirements: 24Vac.
    b) Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
    c) Customized for operation within the confines of equipment served.
    d) Provide sufficient memory to support controller’s operating system, database, and programming requirements.
    e) Communication with other network devices to be based on assigned protocol.
        1) Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
    f) Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
2. Communication:
    a) Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
3. Anticipated Environmental Ambient Conditions:
    a) Outdoors and/or in Wet Ambient Conditions:
        1) Mount within NEMA 4X waterproof enclosures.
        2) Rated for operation at 40 to 150 degrees F.
    b) Conditioned Space:

1) Mount within NEMA 1 dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F and 95 percent RH, non-condensing.

4. Provisions for Serviceability:

a) Diagnostic LEDs for power, communication, and processor.
b) Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory. In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:

a) Maintain operation at 90 to 110 percent of nominal voltage rating.
b) Perform orderly shutdown below 80 percent of nominal voltage.
c) Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention.
d) Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

7. Surge and Transient Protection:

a) Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
b) Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

F. Input/Output Interface

1. Hardwired inputs and outputs shall tie into the BAS through building, custom application, or application specific controllers.
2. All Input/Output Points:

a) Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
b) Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
c) Universal-type inputs or outputs configurable between binary and analog are acceptable.

3. Binary Inputs:

a) Allow monitoring of On/Off signals from remote devices.
b) Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.

c) Sense dry contact closure with power provided only by the controller.

4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:

a) Allow for monitoring of low voltage 0 to 10 Vdc, 4 to 20 mA current, or resistance signals (thermistor, RTD).
b) Compatible with and field configurable to commonly available sensing devices.

6. Binary Outputs:

a) Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
b) Outputs provided with three position (On/Off/Auto) override switches.
c) Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.

7. Analog Outputs:

a) Monitoring signal provides a 0 to 10 Vdc or a 4 to 20 mA output signal for end device control.
b) Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
c) Drift to not exceed 0.4 percent of range per year.

8. Tri State Outputs:

a) Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
b) Limit the use of three point, floating devices to the following zone and terminal unit control applications:

1) VAV terminal units.
2) Duct mounted heating coils.
3) Zone dampers.
4) Radiant devices.

c) Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.04 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Power Wiring: Copper wiring, plenum cable, and raceways shall be as specified in the applicable section of Division 26.

B. Power and Communication Wiring Transient Protection:

1. Comply with IEEE C62.41.2.
2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection required.
3. Communication circuitry, input/output circuitry, and communication unit shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations.
    a) For systems not complying with this requirement, provide equivalent protection external to the automatic temperature control system controller. Protection shall be provided for the individual communications and input/output terminations for each automatic temperature control system controller.
    b) Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

C. Power Supplies:

1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
2. Limit connected loads to 80 percent of rated capacity.
3. Match DC power supply to current output and voltage requirements.
4. Supplies shall be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
7. Operational Ambient Conditions: 32 to 120 degrees F.
8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
9. Line voltage units UL recognized and CSA approved.

D. Power Line Filtering:

1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
2. Minimum surge protection attributes:
    a) Dielectric strength of 1000 volts minimum.
    b) Response time of 10 nanoseconds or less.
    c) Transverse mode noise attenuation of 65 dB or greater.
    d) Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

E. Input/Output Control Wiring

1. Control wiring shall be sized to accommodate the voltage drop associated with the distance between the control device and the controller. Minimum size shall be as specified herein.
2. In all communication conduits, provide one spare twisted pair to be installed, tagged and labeled at each end.
3. Control wiring not installed in conduit shall be UL rated for plenum installation.
4. Ethernet control wiring shall be fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
5. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gauge.
6. Other analog inputs shall be a minimum of number 22 gauge, twisted, shielded.
7. Binary control function wiring shall be a minimum of number 18 gauge.
8. Analog output control functions shall be a minimum of number 22 gauge, twisted, shielded.
9. Binary input wiring shall be a minimum of number 22 gauge, twisted, shielded.
10. Thermistors shall be equipped with the manufacturer's calibrated lead wiring.
11. 120V control wiring shall be #14 THHN in 3/4 inch conduit. Provide 20% fill extra wire in each conduit.

F. Splices: Splices in shielded cables shall consist of terminations and the use of shielded cable couplers that maintain the integrity of the shielding.

G. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: EMT with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

H. Relays

1. Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
2. Solid State Relays (SSR):

   a) Input/output isolation: Greater than 10 E^9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz.
   b) Contact Life: 10 x 10 E^6 operations or greater.

c) Ambient Temperature Range: Minus 20 to +140 degrees F.
d) Input impedance: Not be less than 500 ohms.
e) Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.

3. Contactors:

a) Type: Single coil, electrically operated, mechanically held, double-break, silver-to-silver type protected by arcing contacts.
b) Positive locking shall be obtained without the use of hooks, latches, or semi permanent magnets.
c) The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

2.05 SYSTEM SOFTWARE

A. General:

1. Provide all necessary system software to form a complete operating system for all operator interface devices.
2. System software shall integrate with all controller software and allow management of software applications at the operator workstation.
3. System software display language: English.

B. Device Profile: BACnet devices shall Conform to the following device profiles as specified in ASHRAE/ANSI 135 BACnet Annex L:

1. Operator workstation: BACnet Advanced Workstation (B-AWS).
2. Building Controller: BACnet Building Controller (B-C).
3. Advanced Application Controller: BACnet Advanced Application Controller (B-AAC).
4. Application Specific Controller: BACnet Application Specific Controller (B-ASC).

C. Software Programming:

1. Provide programming for the system and adhere to the sequences of operation provided. Provide actions for all possible situations. All other system programming necessary for the operation of the system shall be provided by the Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Provide text-based, graphic-based, and parameter-based programming where appropriate.

D. Operating System:

1. Concurrent, multi-tasking capability.
2. Common Software Applications Supported:

    a) Microsoft Windows and Microsoft Office Suite.
    b) Open platform compatible database: Microsoft Access, Oracle Database, IBM Analytics, or other SQL database software. Proprietary databases shall not be acceptable.

3. Acceptable Operating Systems: Most recent version of operating system.

E. System Graphics:

1. Color type, saved in an industry-standard format such as BMP, JPEG, PNG, or GIF.
2. Allow simultaneous display for comparison and monitoring of system status.
3. Web based graphics shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X, Java Virtual Machine, and Adobe Flash).
4. Animate displayed objects by shifting image files of objects based on object status.
5. Functionality: Provide method for operator with password to perform the following:

    a) Move between, change size, and change location of graphic displays.
    b) Modify on-line.
    c) View a summary of the most important data for each controlled zone or piece of equipment.
    d) View a summary of the most important global data for the project, including but not limited to date, day of week, time, outdoor dry bulb temperature, and humidity.
    e) Use point-and-click navigation between graphic screens.
    f) Edit setpoints and other specified parameters.

a. Edit equipment names and numbers.
b. Edit room names and numbers.

    g) Indicate areas or equipment in an alarm condition using color or other visual indicator.
    h) Add, delete, or change dynamic objects consisting of:

        1) Analog and binary values.
        2) Dynamic text.
        3) Static text.
        4) Animation files.

    i) Display graphic file, text, and dynamic object data together on a single graphic. Display all measured and commanded data, setpoints, calculated values, and input and output control points with appropriate engineering units associated with each system schematic.

j) Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

k) Dynamic Data Displays shall be capable of including point data from multiple ASC's.

6. Include at least one graphic for each of the following:

a) Each piece of equipment.

b) Occupied zone.

c) Hydronic system (chilled water, condenser water, hot water, steam, heat pump, etc.)

d) Floor plan displays of the building. Indicate summary conditions for each floor.

e) Indicate thermal comfort on floor plan using dynamic colors to represent zone temperature relative to zone setpoint.

2. Graphic Tree Structure:

f) Structure graphic system tree to allow access to individual graphic screens from a macro to a micro level.

g) Allow each level of graphic direct access to the graphic screen above and below the graphic screen in the system tree.

h) Allow direct access to the main summary graphic screen/map from any individual graphic screen.

7. Sequence of Operation Graphics:

a) Display the complete Sequence of Operation or include a link to a separate text file that contains the sequence of operation, as submitted by the Contractor and approved by the Engineer with each system schematic view. The Sequence of Operation text shall be in a separate frame above, below, or to the side of the graphic as appropriate for the graphic size and content.

8. Custom Graphics Generation Package:

a) Allow operator to create, delete, modify, and save custom graphic files and displays. File format of graphics shall be compatible with BAS software.

b) Web-based Graphics: HTML graphics to support web browser compatible formats.

c) The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard components with which custom graphics may be built. Standard components include but are not limited to

1) Air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.).

2) Complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.).
3) Hydronic system components (e.g., chillers, boilers, pumps, piping, valves, etc.).
4) Electrical symbols.

d) The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following

1) Define symbols.
2) Position and size symbols.
3) Define background screens.
4) Define connecting lines and curves.
5) Locate, orient and size descriptive text.
6) Define and display colors for all elements.
7) Establish correlation between symbols or text and associated system points or other displays.
8) Capture or convert graphics from AutoCAD.

e) Graphical displays shall be capable of representing a group of objects. Groups shall be capable of representing any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the building.

3. Standard HVAC Graphics Library: Furnish a complete library of standard HVAC equipment graphics and standard symbols for ancillary equipment in a file format compatible with the graphics generation package program. Graphics shall include, but not be limited to, the following:

a. HVAC Equipment:

1) Chillers.
2) Boilers.
3) Air Handlers.
4) Terminal HVAC Units.
5) Fan Coil Units.

b. Ancillary Equipment:

1) Fans.
2) Pumps.
3) Coils.
4) Valves.
5) Piping.
6) Dampers.
7) Ductwork.

F. Workstation System Applications:

1. General Application Functions:

   a) All applications shall be capable of being executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization.
   b) Allow BAS configuration and future changes or additions by operators with password protection.
   c) Execute configured processes defined by the user to automatically perform calculations and control routines.
   d) Process Inputs and Variables: It shall be possible to use any of the following in a configured process:

      1) Any system-measured point data or status
      2) Any calculated data
      3) Any results from other processes
      4) Boolean logic operators (and, or)

   e) Process Triggers: Configured processes may be triggered based on any combination of the following:

      1) Time of day
      2) Calendar Date
      3) Other processes
      4) Events (e.g., point alarms)

   f) Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASC's. In addition, a single process shall be able to issue commands to points in any and all other ASC's on the local network.

2. Network Configuration:

   a) Allow for configuration of the BAS network.
   b) Provide alarm when a break in communication between devices is detected.
   c) Enable the operator to add, delete, or modify the following:

      1) Building controllers and ASC's.
      2) Points of any type, point parameters, and tuning constants.

   d) Provide automatic reconfiguration if any station is added or lost.

3. Save and Restore:

   a) Automatic System Database Save and Restore Functions:

      1) Store current database copy of each Building Controller on hard disk or server.
      2) Backup database on a user adjustable frequency basis. Default frequency shall be monthly.
      3) Automatically update upon change in any system panel.

4) In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.

b) Manual System Database Save and Restore Functions by Operator with Password Clearance:

1) Save database from any system panel.
2) Clear a panel database.
3) Initiate a download of a specified database to any system panel.

4. On-line Help:

a) Include context-sensitive system to assist operator in operation and editing.
b) Include topics available for all applications.
c) Include relevant screen data provided for particular screen display.
d) Include additional help via hypertext.

5. Security:

a) Require user name and password for Operator log-on to view, edit, add, or delete data.
b) Include selectable system security for each operator. Support a minimum of five levels of access:

1) Level 1 = Read-only data access and display.
2) Level 2 = Level 1 + scheduling.
3) Level 3 = Level 2 + operator overrides and commands.
4) Level 4 = Level 3 + database generation and modification.
5) Level 5 = Level 4 + Audit trail management.
6) Operators shall be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only the items defined as accessible for the user.
7) Support a minimum of 4 passwords at each Building Controller.

c) Allow system supervisor to set passwords and security levels for all other operators.
d) Allow operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
e) Include automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
f) Store all system security data in encrypted format.
g) Log all user actions and store data for audit with permission access by system administrator only.

1) Include the modified system.
2) Include the value modified.

3) Include the time of modification.

6. System Diagnostics:

   a) Operations Automatically Monitored:

      1) Workstations.
      2) Printers.
      3) Network connections.
      4) Building management panels.
      5) Controllers.

   b) Device failure is annunciated to the operator.

7. Alarm Management:

   a) Allow alarm prioritizing to minimize nuisance reporting and to speed operator response to critical alarms.

      1) Provide a minimum of three, user definable priority levels.
      2) Enable users to manually inhibit alarm reporting for each point.
      3) Enable users to manually inhibit nuisance alarm reporting for maintenance or repair work that is scheduled to be performed.
      4) Enable user to define conditions under which point changes need to be acknowledged by an operator, and/or logged for analysis at a later date.
      5) Allow alarm prioritization to lock out or circumvent other alarms that may be generated as a result of primary alarm.

   b) Prohibit interference with the ability of the system software to report alarms by either operator activity at the local I/O device, or communications with other system controllers on the network.
   c) Allow all system objects that are configurable to "alarm in" and "alarm out" of normal state.
   d) Configurable Objects:

      1) Alarm limits.
      2) Alarm limit differentials.
      3) States.
      4) Reactions for each object.
      5) Alarm delay.

   e) Alarm Messages:

      1) Descriptor: English language. Acronyms or mnemonics for objects in alarm are not acceptable.
      2) Recognizable Features:

         a) Source.
         b) Location.
         c) Nature.

d) Time and Date.

e) Alarm message box to more fully describe the alarm condition or direct operator response.

f) Each Alarm messages shall be assignable to any point in the BAS. Alarm messages shall be assignable to multiple points.

a) Notification of an alarm override.

f) Configurable Alarm Reactions by Workstation and Time of Day:

1) Logging.
2) Printing.
3) Starting programs.
4) Displaying messages.
5) Phone text message.
6) Email.
7) Providing audible annunciation.
8) Displaying specific system graphics.

8. Custom Trend Logs:

a) Maintain trend information for minimum 365 days.

b) Definable for any data object in the system including interval, start time, and stop time.

1) Resolution: Interval periods shall be adjustable down to one minute.
2) Multiple Interval Period: Each trended point shall have the ability to be trended at a different trend interval.

c) Trend Data:

1) Sampled and stored on the building controller panel.
2) Auto-Delete Period: Software shall be capable of automatically deleting stored trend data after a user-adjustable period of time. Each trended point shall have the ability to have a different auto-delete interval period.
3) Archivable on hard disk or server.
4) Retrievable for use in reports, spreadsheets and standard database programs.
5) Protected and encrypted format to prevent manipulation or editing of historical data and event logs.

d) Trend Graph Display:

1) Group Trend Time Series Plots:

a) Provide user-selectable Y-axis points.

b) Provide user editable titles, point names, and Y-axis titles.

c) Individual trended points shall be able to be grouped into groups of up to four points per plot with up to four plots per page.

2) X-Y Trend Plots:

a) User selectable X and Y trend inputs.
b) User editable titles, point names, and X and Y-axis titles.
c) User selectable time period options:

i) 1-day 24-hour period.
ii) 1-week 7-day period.
iii) 1-month period with appropriate days for the month selected.
iv) 1-year period.
v) User shall be able to select the beginning and ending period for each X-Y chart, within the time domain of the database being used.
vi) User selectable display up to 6 plots per screen in 2 columns.

3) Automatic Scaling: System shall automatically scale the axis on which trends are displayed when multiple points with different trend interval periods are selected for graphical display.
4) Dynamic Update: Trends shall be able to dynamically update at operator-defined intervals.
5) Zoom: Software shall allow zoom-in function for detailed examination of trends.

e) Numeric Value Display: Software shall display value of any sample on a trend when picked.

9. Alarm and Event Log:

a) View all system alarms and change of states from any system location.
b) List events chronologically.
c. List alarm priority.
c) Allow operator with proper security to acknowledge and clear alarms. Log operator and time when alarm is acknowledged.
d) Archive alarms not cleared by operator to the workstation.

10. Object, Property Status, and Control:

a) Provide a method to view, edit if applicable, the status of any object and property in the system.
b) Status Available by the Following Methods:

1) Menu.
2) Graphics.

3) Custom Programs.

11. Clock Synchronization:

a) The real-time clocks in all building control panels and workstations shall be able to automatically synchronize daily from any operator-designated device in the system.
b) The system shall automatically adjust for daylight savings and standard time, if applicable.

12. Reports and Logs:

a) Reporting Package:

1) Allow operator to select, modify, or create reports.
2) Definable as to data content, format, interval, and date.
3) Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.
4) Provide ability to obtain real-time logs of all objects available by type or status such as alarm, lockout, normal, etc.
5) Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
6) Allow printing on operator command or specific time(s).

b) Standard Report Format Options:

1) Objects with current values.
2) Global modification values.
3) Current alarms not locked out.
4) Disabled and overridden objects, points and variables.
5) Objects in manual or automatic alarm lockout.
6) Objects in alarm lockout currently in alarm.
7) Objects currently in override status.
8) Objects in Schedules

a) Daily.
b) Weekly.
c) Holiday.

9) Logs:

a) Alarm History.
b) System messages.
c) System events.
d) Trends.

c) Custom Report Format Options:

1) Daily.
2) Weekly.
3) Monthly.

4) Annual.
5) Time and date stamped.
6) Title.
7) Facility name.
8) Point Groups.

a) User-selectable.
b) Group may be comprised of specific points, group of equipment objects, group of groups, or for the entire facility without restriction due to the hardware configuration of the BAS.

d) Electrical, Fuel, and Weather:

1) Electrical Meter(s):

a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.

2) Fuel Meter(s):

a) Monthly showing daily fuel consumption for each meter.
b) Annual summary showing monthly consumption for each meter.

3) Weather:

a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.

e) Daily Operating Condition of Chiller(s): Program a daily report that shows the operating condition of each chiller as recommended by ASHRAE Standard 147. Reference the control drawings for the points that shall be included in the log report.

13. Global Modify:

a) Allow global modification of all editable data. Similar data shall be grouped into logical objects based on building function, mechanical system, building layout, or any other logical grouping of points.
b) Allow each common type of equipment to be excluded or included within the global editing process.
c) Display status information on all similar points in one global report.
d) Allow modification of the following:

1) Individual data point edited.
2) List of all points within the category.

3) Global change field.
4) Copy feature to assist in downloading the new changes.
5) Verification that all changes were completed.

e) Include a change-all feature to change all selections.
f) Prevent acceptance of changes until an accept icon is acknowledged.

G. Workstation Applications Editors:

1. Provide editing software for each system application at the PC workstation.
2. Edited applications shall be automatically downloaded and executed at the controller panel.
3. Programming Description: Definition of operator device characteristics, ASC's, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.
4. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hard copy printouts of all configuration and application data.
5. System definition and modification procedures shall not interfere with normal system operation and control.
6. Provide consistent text-based displays of all system point and system applications.
7. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.
8. Full screen editor for each application shall allow operator to view and change:

a) Configuration.
b) Name.
c) Control parameters.
d) Set-points.
e) Schedules.

9. Scheduling:

d. Allow scheduling down to the zone or room level.
a) Monthly calendar indicates schedules, holidays, and exceptions.
b) Allows several related objects to be grouped, scheduled, and copied to other objects or dates.
c) Start and stop times adjustable from master schedule.
e. Schedule expiration.
d) Temporary overrides of systems with user adjustable time-out.
f. Provide minimum three tiers of priorities for scheduling.

1) Priority 1: Event, temporary, or override.
2) Priority 2: Calendar.
3) Priority 3: Default.

g. Higher priority schedules shall overlay with lower priority schedules without interrupting or deleting them. Upon expiration of a higher priority schedule, schedule shall revert to next lower priority.

h. Expired priority 1 and priority 2 schedules shall be automatically deleted after execution.

10. Custom Application Programming:

    a) Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.

    b) Programming Features:

        1) English oriented programming language, allowing for free form programming.
        2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
        3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
        4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
        5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
        6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
        7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
        8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values can be used in IF/THEN comparisons, calculations, programming statement logic, etc.
        9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.06 CONTROLLER SOFTWARE

A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.

B. System Security:

1. User access secured via user passwords and user names.
2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
3. User Log On/Log Off attempts are recorded.
4. Automatic Log Off occurs following the last keystroke after a user defined delay time.

C. Object or Object Group Scheduling:

1. Weekly Schedules Based on Separate, Daily Schedules:

    a) Include start, stop, optimal stop, and night economizer.
    b) 10 events maximum per schedule.
    c) Start/stop times adjustable for each group object.

2. Exception Schedules:

    a) Based on any day of the year.
    b) Defined up to one year in advance.
    c) Automatically discarded and replaced with standard schedule for that day of the week upon execution.

3. Holiday or Special Schedules:

    a) Capability to define up to 99 schedules.
    b) Repeated annually.
    c) Length of each period is operator defined.

D. System Coordination: Provide a standard application for equipment coordination. The application shall provide the operator with a method of grouping together equipment based on function and location. Groups shall be capable of being used for scheduling and other applications.

E. Alarms:

1. Binary object is set to alarm based on the operator specified state.
2. Analog object to have high/low alarm limits.
3. All alarming is capable of being automatically or manually disabled.
4. Alarm Reporting:

    a) Operator determines action to be taken for alarm event.
    b) Alarms to be routed to appropriate workstation.

5. Reporting Action Options:

    a) Start Programs.

b) Print.
c) Logged.
d) Custom messaging.
e) Graphical displays.
f) Dial out to workstation receivers via system protocol.

F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.

G. Sequencing: Application software based upon specified sequences of operation on the control drawings.

H. PID Control Characteristics:

1. Provide proportional-integral algorithms.
2. Direct or reverse action.
3. Anti-windup.
4. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
5. User selectable controlled variable, set-point, and PI gains.

I. Staggered Start Application:

1. Prevents all controlled equipment from simultaneously restarting after power outage.
2. Order of equipment startup is user selectable.

J. Anti-Short Cycling:

1. All binary output objects protected from short-cycling.
2. Allows minimum on-time and off-time to be selected.
3. Allows the number of times each piece of equipment may be cycled within any one-hour period.

K. On-Off Control with Differential:

1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.

L. Trending: Building controllers shall allow collection and delivery of (time, value) pairs.

M. Totalization:

1. Run-Time Totalization:

a) Totalize run-times for all binary input objects.
b) Provides operator with capability to assign high run-time alarm.

c) Generates unique, user-specified messages when the limit is reached.
d) Resolution: Adjustable down to one minute.

2. Pulse Totalization:

a) Totalize consumption for user-selected analog and binary pulse input-type objects.
b) Configurable for a daily, weekly, or monthly basis.
c) Provide calculation and storage accumulations of up to 9,999,999 units (e.g. KWH, gallons, KBTU, tons, etc.).
d) Resolution: Adjustable down to one minute.
e) Warning Limit: User definable. Generate unique, user-specified messages when the limit is reached.
f) The information available from the Pulse Totalization shall include, but not be limited to, the following:

1) Peak Demand, with date and time stamp
2) 24-hour Demand Log
3) Accumulated KWH for day
4) Sunday through Saturday KWH usage
5) Sunday through Saturday Demand kW
6) Demand kW annual history for past 12 periods
7) KWH annual history for past 12 periods

3. Event Totalization:

a) Count user-selected events, such as the number of times a pump or fan system is cycled on and off.
b) Provide storage accumulations of up to 9,999,999 events before reset.
c) Warning Limit: User definable. Generate unique, user-specified messages when the limit is reached.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices and wiring are installed prior to installation proceeding.

E. Verify the integrity of control wiring, raceways, control panels, sensors, and control devices prior to reusing for the new work.

F. Verify wiring insulation is defect free and test wiring for continuity and ground faults.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Coordination:

1. Cooperate with other contractors performing work on this project as necessary to achieve a complete and coordinated installation. Each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others work.
2. Coordinate with the Owner to display additional virtual points on individual schematic graphic screens that are not directly associated with that system. Examples may include outdoor air temperature or global alarm conditions.

B. Web Services Enabled Network:

3. Provide an IP network data drop for connection of BAS into Owner's IP network. Coordinate final location of IP network data drop with the Owners' IT staff.
4. If the Owner has no preference or not indicated on the drawings, locate data drop within the main BAS control panel.
5. Coordinate with the Owner's IT department to implement proper security measures, including secure access to the network data drop and firewalls at all virtual access points to the internet to protect access to the BAS.

C. General Workmanship:

1. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.
2. Install all equipment in readily accessible locations.
3. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
4. All installations shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
6. Control wiring routed in wall cavities shall be installed in conduit.
7. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
8. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C. Controllers:

1. Install controllers in a locked control panel. Provide common keying for all controller covers.

2. Provide a separate controller for each piece of controlled equipment, such as an AHU, FCU, VAV box, etc. A controller may control more than one piece of equipment provided that all points associated with the equipment are assigned to the same BAS controller. Global points used for control loop reset are exempt from this requirement.
3. Select building controllers and custom application controllers to provide the required I/O point capacity required to monitor all of the hardware points listed on the control drawings.
4. Application specific controllers may be used where factory programming is capable of executing all control functions specified in the sequences of operation. Contractor shall add supplemental controllers, devices, and programming as required to execute the specified control function if the ASC cannot.

D. Wiring:

1. All control and interlock wiring shall comply with national and local electrical codes.
5. Properly ground all controllers.
6. Wire all safety devices through both hand and auto positions of motor starting device to ensure 100 percent safety shut-off.
2. Provide interlock wiring between devices as indicated on the control drawings.
3. Provide electrical wiring for relays (including power feed) for temperature and pressure indication.
4. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
5. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.
7. Conceal all low voltage wiring in finished rooms.
8. Conceal all low voltage wiring in unfinished rooms below the elevation of the lights. Low voltage wiring above the elevation of the lights may be exposed.
9. Routing of low voltage wiring above working heights in equipment rooms and above accessible ceilings is acceptable subject to following criteria:

a. Wiring shall be plenum rated.
b. Do not lay wiring on ceiling tiles.

6. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended applications.
7. All wiring in mechanical, electrical, service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 10 feet.
8. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used

for low-voltage wiring except for the purpose of interfacing the two wires (e.g., relays and transformers).

9. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it and neatly tied at 10 foot intervals.
10. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
11. All wire-to-device and wire-to-wire connections shall be made at a terminal block or terminal strip.
12. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
13. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, coordinate with Division 26 to provide step-down transformers.
14. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
15. Install plenum wiring in sleeves where it passes through floors and walls. Maintain fire rating at all penetrations.
16. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
17. Include one pull string in each raceway 1 inch and larger.
18. Use coded conductors throughout with conductors of different colors.
19. Control and status relays shall be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
20. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (e.g., steam pipes or flues).
21. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
22. Install insulated bushing on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
23. Terminate all control and/or interlock wiring and maintain updated (as-built) wiring diagrams with terminations identified at the job site.
24. Terminate BAS sensor input wiring cable shield by taping back at the field device and connect shield to the grounded control panel chassis or sub-panel.
25. Terminate BAS comm bus cable shield between controllers per manufacturer recommendations.
26. Terminate management level/enterprise level network wiring cable shield by wrapping the drain wire around the foil shield and connecting the ground strip to the drain wire.

27. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than 1/2 inch electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
28. Raceway shall be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations shall be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

E. Communication Wiring:

1. Adhere to the items listed in the “Wiring” article in Part 3 of this specification in addition to the requirements listed below.
2. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication wiring.
3. Do not exceed 328 feet in Ethernet wiring length between switches or repeaters.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
5. Do not install power wiring, in excess of 30 Vac RMS, in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, use separate twisted shielded pairs with the shields grounded in accordance with the manufacturer’s wiring practice.
6. Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
7. Do not exceed maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer during installation.
8. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
9. When a cable enters or exits a building, install a lightning arrestor between the lines and ground. Install the lightning arrestor according to the manufacturer’s instructions.
10. Ground (earth ground) all shields at one point only, to eliminate ground loops.
11. All runs of communications wiring shall be unspliced length when that length is commercially available.
12. Terminate shielded cable splices in accessible locations. Harness cables with cable ties.
13. Make all wire-to-device and wire-to-wire connections at a terminal block or terminal strip.
14. Label all communications wiring to indicate origination and destination data.
15. Ground coaxial cable in accordance with NEC regulations.

16. Install BACnet MS/TP communications wiring in accordance with ASHRAE/ANSI Standard 135
    a) The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 17 pF per foot at 76,800 Baud.
    b) The maximum length of an MS/TP segment shall be 3000 ft with AWG 22 or 24 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
    c) The maximum number of nodes per segment shall be 50. Additional nodes may be accommodated by the use of repeaters.
    d) An MS/TP EIA-485 network shall have no T connections.

F. Fiber Optic Cable System:

1. Do not exceed maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer during installation.
2. Install all cabling and associated components in accordance with manufacturer’s instructions. Maintain minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer.

G. Identification of Hardware and Wiring:

1. Label all wiring and cabling, including that within factory-fabricated panels, at each end within 2 inch of termination with the BAS address or termination number.
2. Permanently label or code each point of field terminal strips to show the instrument or item served.
3. Identify control panels with minimum 1/2 inch letters on laminated plastic nameplates.
4. Identify all other control components with permanent labels. Label all plug-in components such that removal of the component does not remove the label.
5. Identify room sensors related to terminal box or valves with nameplates.
6. Maintain manufacturers’ nameplates and UL or CSA labels visible and legible after equipment is installed.
7. Identifiers shall match record documents.

3.03 STARTUP AND DEMONSTRATION

A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing the BAS in permanent operation.

B. Contractor shall provide an on-site controls technician or programmer familiar with the project BAS installation and system programming to assist the Commissioning Agent as directed during all phases of system functional testing.

C. Coordinate with Owner the setup of logins, passwords, and security level access for individuals requiring access to the BAS.

D. BAS graphics shall be updated with final equipment names, equipment numbers, room names and room numbers to match the final construction documents and any Owner changes made prior to occupancy.

D. BAS shall be set up and checked by factory trained technicians skilled in the setting and adjustment of the BAS equipment used in this project. Technicians shall be experienced in the type of HVAC systems associated with this project.

E. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

F. Test each control device to ensure that it is operating properly and is calibrated to the appropriate operating requirements. Run each control device through its range of operation and sequence. Verify all normal positions are correct. Adjust and tune PID control constants to achieve proper system operation.

1. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
2. Demand limiting. The Contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
3. Optimum start/stop. The Contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
4. Any tests that fail to demonstrate the operation of the BAS shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

G. Test and verify control interfaces to other building systems integrated into the network.

H. Verify all alarms and interlocks.

1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

4. Verify fire/smoke and smoke damper functionality. Verify that they respond to the proper fire alarm system general, zone, and/or detector trips.

I. Document on system equipment schedules the final setting of controller PID constant settings, setpoints, manual reset values, maximum and minimum controller output, and ratio and bias settings in units and terminology specific to the controller. Store documentation with operator workstation.

J. Demonstrate complete and operating system to Owner.

1. Prior to acceptance, the BAS shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, start-up, and debugging process.
3. The Contractor shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. Any test equipment required to provide the proper operation shall be provided by and operated by the Contractor.
4. Demonstrate compliance with sequences of operation through all modes of operation.
5. Demonstrate complete operation of operator interface.

K. Acceptance:

1. All tests described in this specification shall have been performed to the satisfaction of the Owner prior to the acceptance of the BAS as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the completion requirements if stated as such in writing by the Contractor and submitted for approval by the Owner. Such tests shall then be performed as part of the warranty.
2. The BAS shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved.

3.04 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for one year from Date of Substantial Completion.

3.05 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train

Owner's designated personnel for a minimum of sixteen hours on the operation and maintenance of the equipment provided under this section.

B. Organize the training into sessions or modules for different levels of operators. Owner designated personnel shall be trained based on the level of operator training described below.

C. Day-to-day Operator Training:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Proficiently operate the BAS.
3. Understand BAS architecture and configuration.
4. Understand BAS components.
5. Understand system operation, including BAS control and optimizing routines (algorithms).
6. Operate the workstation and peripherals.
7. Log on and off the system.
8. Access graphics, point reports, and logs.
9. Adjust and change system set points, time schedules, and holiday schedules.
10. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
11. Understand BAS drawings and Operation and Maintenance manual.
12. Understand the job layout and location of control components.
13. Access data from BAS controllers and ASCs.
14. Operate portable operator’s terminals.
15. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.

D. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

E. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided.

F. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Hydronic system requirements.

B. Hydronic piping materials.

C. Hydronic piping fittings.

D. Hydronic piping joining materials.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.

B. Reference Division 23 Section, “Basic Piping Materials and Methods” for additional submittal requirements.

C. Reports as specified in Part 3 of this Section.

1.04 QUALITY ASSURANCE

A. Comply with Division 23 Section, “Basic Piping Materials and Methods.”

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this Section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing work of the type specified in this Section, with minimum three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Comply with Division 23 Section, “Basic Piping Materials and Methods.”

PART 2 - PRODUCTS AND MATERIALS

2.01 HYDRONIC PIPING MATERIALS

A. Carbon Steel Pipe:

1. NPS 2 inch and Smaller: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40, black steel, plain ends.
2. NPS 2-1/2 inch through 10 inch: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40, black steel, plain or beveled ends.
3. NPS 12 inch and Larger: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule STD, black steel, plain or beveled ends.

B. Stainless Steel Pipe:

1. NPS 2 inch and Smaller: ASTM A312, Type 304 or 316, Schedule 10S, plain ends.
2. NPS 2-1/2 inch and larger: ASTM A312, Type 304 or 316, Schedule 10S, plain or beveled ends.

C. Copper Tubing:

1. Drawn Temper Tubing: ASTM B88, Type M.
2. Drawn Temper Tubing: ASTM B88, Type L.
3. Annealed Temper Tubing: ASTM B88, Type K.

2.02 HYDRONIC PIPING FITTINGS:

A. General: Fittings shall be of wall thickness, pressure rating, and material matching adjoining pipe.

B. Reference Division 23 Section “Basic Piping Materials and Methods” for basic piping materials and fittings.

C. Threaded:

1. All threads shall conform to ASME B1.20.1.
2. Malleable-Iron: ASME B16.3, standard pattern.
3. Cast-Iron: ASME B16.4, standard pattern.
4. Cast-Stainless Steel: ASTM A351, standard pattern.
5. Galvanized: ASTM A197, standard pattern.

D. Flanged:

1. Cast-Iron Threaded: ASME B16.1, raised ground face, bolt holes spot faced.
2. Cast-Bronze Flanges: ASME B16.24, raised ground face, bolt holes spot faced.

1. Galvanized Threaded: ASME B16.5, raised ground face, bolt hols spot faced.

3. Wrought Cast-Iron, Forged Steel, and Stainless Steel: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connection, and facing:

   a) Material Group: 1.1.
   b) End Connections: Butt welding.
   c) Facings: Raised face.

4. Gaskets: ASME B16.21, non-metallic, asbestos free, 1/8 inch thick, full-face for cast-iron flanges and raised-face steel flanges, suitable for chemical and thermal conditions of piping system contents.
5. Flange bolts and nuts: ASME B18.2.1, hex head carbon steel according to ASTM A307, Grade B.

E. Welded:

1. Carbon and Galvanized Steel: ASME B16.9, seamless weld conforming to ASTM A234.
2. Wrought Stainless Steel: ASME B16.9, seamless weld conforming to ASTM A403.

F. Solder-Joint: Wrought-copper, ASME B16.18 or B16.22, streamlined pattern.

G. Brazed-Joint: Wrought-copper, ASME B16.50, streamlined pattern.

H. Transition Fittings for plastic to metal piping shall be of the plastic material of the adjoining pipe, one-piece, with a threaded brass or copper insert and schedule 80 solvent cement or fusion end.

2.03 HYDRONIC PIPING JOINING MATERIALS:

A. Reference Division 23 Section “Basic Piping Materials and Methods” for basic joining materials.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer’s instructions.

B. Install piping to ASME B31.9 requirements.

C. Reference Division 23 Section “Basic Piping Materials and Methods” for general piping installation requirements.

D. Do not install PVC or non-plenum rated CPVC piping in return air plenums.

3.02 PIPE APPLICATION SCHEDULE

A. Mechanically Joined Hydronic Piping:

1. Contractor may provide mechanically joined hydronic piping systems as an option in lieu of, in whole of, or in part of, the pipe fitting and joining methods for the specific systems indicated in Article “Pipe Applications.” Reference Division 23 Section “Mechanically Joined Hydronic Piping Systems.”
2. Contractor shall not use mechanically joined hydronic piping systems for hydronic piping in lieu of welded, threaded or flanged piping methods.

   a) Exception: Grooved couplings may be used at equipment connections where specified for vibration isolation control only.

B. Heating Hot Water Piping, Above Grade:

1. Acceptable Pipe Materials:

   a) Carbon steel with threaded fittings for pipes 2 inch and smaller, and flanged or welded fittings for pipes 2-1/2 inch and larger.
   b) Type L copper with soldered, brazed, or flanged fittings.
   c) Stainless steel with threaded fittings for pipes 2 inch and smaller, and flanged or welded fittings for pipes 2-1/2 inch and larger.

2. Fitting Pressure Class: Minimum rating of 150 psig.

C. Chilled Water Piping, Above Grade:

1. Acceptable Pipe Materials:

   a) Carbon steel with threaded fittings for pipes 2 inch and smaller, and flanged or welded fittings for pipes 2-1/2 inch and larger.
   b) Type L copper with soldered, brazed, or flanged fittings.
   c) Stainless steel with threaded fittings for pipes 2 inch and smaller, and flanged or welded fittings for pipes 2-1/2 inch and larger.

2. Fitting Pressure Class: Minimum rating of 150 psig.

3.03 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment using jointing system specified.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.04 PIPING INSTALLATION

A. Provide long radius elbows with a minimum centerline radius of 1-1/2 times the pipe diameter. Short radius elbows with a minimum centerline radius of 1 times the pipe diameter may be used only where space does not permit the long radius elbows.

B. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

C. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

D. Install branch connections to mains using Tee fittings in main with take-off out the top or side of the main unless otherwise shown on the drawings. Up-feed risers shall have take-off out the top of the main line.

1. Tee-drilling is prohibited as a means for connecting branch taps into any main.
2. Bull-head tees are prohibited. Do not install tee fittings in such a way that the flow through the branch leg equals the sum of the flows through the two main legs.

E. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings and specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

3.05 PIPE HANGERS AND SUPPORTS APPLICATION

C. Comply with the requirements of Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

A. Provide vibration isolation on piping as specified in Division 23 Section "Vibration Isolation for HVAC."

B. Install hangers with the following minimum rod sizes and maximum spacing:

Nom. Pipe Size - In.	Steel Pipe Max. Span - Ft.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to 3/4	7	5	3/8
1	7	6	3/8
1-1/4	7	7	3/8
1-1/2	9	8	3/8
2	10	8	1/2
2-1/2	11	9	1/2
3	12	10	1/2
4	14	12	5/8 (1/2 for copper)
5	16	13	5/8 (1/2 for copper)
6	17	14	3/4 (5/8 for copper)
8	19	16	7/8 (3/4 for copper)

10	20	18	7/8 (3/4 for copper)
12	23	19	7/8 (3/4 for copper)

C. Support vertical runs at roof, at each floor, and at maximum 15-foot intervals between floors.

D. Install a support within one foot of each change of direction.

E. Space supports not more than five feet apart at valves, strainers, or piping accessories in piping larger than 2 inches.

3.06 PIPE JOINT CONSTRUCTION

A. Reference Division 23 Section, “Basic Piping Materials and Methods” for basic pipe joint construction.

B. Where more than one pipe material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.

C. Install non-conductive dielectric connections whenever joining dissimilar metals.

D. Pipe-to-Valve and Pipe-to-Equipment Connection: Install flanges or unions between piping and valves and equipment for servicing. Do not use direct welded, brazed, or soldered connections unless specifically called for in the manufacturer’s installation instructions.

3.07 FIELD QUALITY CONTROL

A. Preparation for Testing:

1. Prepare hydronic piping in accordance with ASME B31.9.
2. Leave joints, including welds, uninsulated and exposed for examination during the test.
3. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
4. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
5. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Pressure Testing:

1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
2. Use vents installed at high points in the system to release trapped air while filling and prevent vacuum while draining the system. Use drains installed at low points for complete removal of the liquid.
3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
4. Subject piping system to a hydrostatic test pressure which at every point in the system is 1.5 times the maximum system design pressure but not less than 100 psi. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix I of ASME B31.9, Code For Pressure Piping, Building Services Piping.
5. After the hydrostatic test pressure has been applied for at least 15 minutes examine piping, joints, and connections for leaks. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.
6. Provide test reports summarizing the test procedures and results of the tests.

C. Flushing:

1. After satisfactory pressure test is obtained, flush piping system using a minimum velocity of 4 FPS through all portions of the system.
2. Make all provisions required to isolate HVAC equipment, coils, control valves, automatic flow control valves, pressure independent control valves, and balance valves during flushing.
3. Provide temporary valves, connections, and bypasses where required.
4. System pumps may be used for flushing. Where system pumps are not used, provide temporary pumps with temporary connections.
5. Continue flushing until discharge water shows no discoloration and strainers are no longer collecting dirt and other foreign materials.
6. Upon completion of flushing, drain all water from system at low points, and remove, clean, and replace strainers.
7. Open vents installed at high points in the system to release trapped air while filling and prevent vacuum while draining the system.

D. Fluid Testing: After filling the system as described under Paragraph “Startup”, perform the following fluid test procedures:

1. Circulate the fluid for a minimum of 24 hours with all pumps operating and with shutoff valves and control valves in wide open position to ensure thorough mixing of the antifreeze or glycol solution throughout the system.
2. Remove fluid from a minimum of three different locations and test fluid samples at an independent testing agency for percentage of antifreeze or

glycol. Coordinate with the testing agency for amount of sample needed for proper testing.

3. If any sample does not meet the specified percentages, remove sufficient fluid from the system, add antifreeze or glycol as required to achieve the specified percentage and repeat the circulation and testing procedures specified above. Coordinate with the water treatment supplier.
4. After the samples meet the specified percentages, submit to the Owner and Engineer signed and dated test report(s) from independent testing agency that document the location of the sample and the results of the fluid test.
5. One month prior to end of the warranty period, Contractor shall submit samples to an independent testing agency to test the fluid for percentage of antifreeze or glycol. If the test samples have the specified percentage, submit copies of the test reports to the Owner and Engineer as described above in Paragraph 4. If any sample does not meet the specified percentage, Contractor shall perform the work described above in Paragraphs 3 and 4.

3.08 ADJUSTING AND CLEANING

A. After installation of entire system, fill, clean, and treat systems. Refer to Section 232500 HVAC Water Treatment for additional requirements.

B. Cleaning Agent Concentration:

1. Use neutralizer agents on recommendation of system cleaner supplier and approval of Engineer.

C. Hot Water Heating Systems:

1. Apply heat while circulating, slowly raising temperature to 160 F and maintain for 12 hours minimum.
2. Remove heat and circulate to 100 F or less, drain systems as quickly as possible.
3. Refill with clean water and circulate for 6 hours at design temperatures, then drain.
4. Refill with clean water and repeat until system cleaner is removed.

D. Chilled Water Systems:

1. Circulate for 48 hours, then drain systems as quickly as possible.
2. Refill with clean water, circulate for 24 hours, then drain.
3. Refill with clean water and repeat until system cleaner is removed.

E. Open vents installed at high points in the system to release trapped air while filling and prevent vacuum while draining the system.

F. Remove and clean or replace strainer screens.

G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

H. After cleaning system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

I. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

J. Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

K. Inspect valves for leaks after piping systems have been tested and put into service, but before final adjusting and balancing. Adjust or replace packing, as required, on valves with leaks. Replace valve if leak persists.

3.09 STARTUP

A. Fill system and perform initial chemical treatment. For systems with antifreeze or glycol, fill systems with specified percentages. Refer to Division 23 Section “HVAC Water Treatment” for chemical treatment.

B. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:

1. Heating Hot-Water Piping: Minimum 30 percent.
2. Chilled-Water Piping: Minimum 30 percent.

C. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

D. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper direction of correct improper wiring.
4. Set automatic fill valves for required system pressure.
5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check operation of automatic bypass valves.
8. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
9. Lubricate motors and bearings.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Buried piping requirements.

B. Pre-insulated piping system, buried.

C. Expansion Cushions.

D. Manholes.

1.02 DEFINITIONS

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

1.03 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

B. Sequencing:

1. Document and mark existing utilities prior to starting excavation.
2. Ensure that utility connections are achieved in an orderly and expeditious manner.

1.04 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.

B. Reference Division 23 Section, “Basic Piping Materials and Methods” for additional submittal requirements.

C. Reports as specified in Part 3 of this Section.

1.05 QUALITY ASSURANCE

A. Comply with Division 23 Section, “Basic Piping Materials and Methods.”

B. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this Section, with minimum three years of documented experience.

C. Installer Qualifications: Company specializing in performing work of the type specified in this Section, with minimum three years of documented experience.

D. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Division 23 Section, “Basic Piping Materials and Methods.”

PART 2 - PRODUCTS AND MATERIALS

2.01 BURIED HYDRONIC SYSTEM REQUIREMENTS

A. Coordinate the material type and pressure class of underground piping with above ground piping systems specified in other Division 23 sections. Provide required transition fittings and adapters where different materials are specified for above ground and underground joined piping systems.

B. Mechanically Joined Hydronic Piping:

1. Contractor shall not use mechanically joined hydronic piping systems for hydronic piping in lieu of welded, threaded or flanged piping methods.

C. Antifreeze and Water Treatment:

2. Refer to Division 23 Section “HVAC Water Treatment” for antifreeze and water treatment products.

D. Piping Materials:

3. Carbon Steel Pipe:

a) NPS 2 inch and Smaller: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40 and Schedule 80, black steel, plain ends.
b) NPS 2-1/2 inch through 10 inch: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40 and Schedule 80, black steel, plain or beveled ends.

2. Galvanized Steel Pipe:

a. NPS 2 inch and Smaller: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40 hot-dipped galvanized according to ASTM A123 on both inside and outside of pipe, plain ends.
b. NPS 2-1/2 inch through 10 inch: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40 hot-dipped galvanized according to ASTM A123 on both inside and outside of pipe, plain or beveled ends.

3. Stainless Steel Pipe:

c. NPS 2 inch and Smaller: ASTM A312, Type 304 or 316, Schedule 10S, plain ends.

a) NPS 2-1/2 inch and larger: ASTM A312, Type 304 or 316, Schedule 5S, plain or beveled ends.

4. Copper Tubing:

a) Copper Tube Size (CTS): ASTM B88, Type K, drawn.

E. Fittings:

1. General: Fittings shall be of wall thickness, pressure rating, and material matching adjoining pipe.
2. Reference Division 23 Section “Basic Piping Materials and Methods” for additional fittings.
3. Threaded:

a) All threads shall conform to ASME B1.20.1.
b) Malleable-Iron: ASME B16.3, standard pattern.
c) Cast-Iron: ASME B16.4, standard pattern.
d) Cast-Stainless Steel: ASTM A351, standard pattern.

4. Flanged:

a) Cast-Iron Threaded: ASME B16.1, raised ground face, bolt holes spot faced.
b) Cast-Bronze Flanges: ASME B16.24, raised ground face, bolt holes spot faced.
c) Wrought Cast-Ironand Stainless Steel: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connection, and facing:

1) Material Group: 1.1.
2) End Connections: Butt welding.
3) Facings: Raised face.

d) Gaskets: ASME B16.21, non-metallic, asbestos free, 1/8 inch thick, full-face for cast-iron flanges and raised-face steel flanges, suitable for chemical and thermal conditions of piping system contents.
e) Flange bolts and nuts: ASME B18.2.1, hex head carbon steel according to ASTM A307, Grade B.

5. Welded:

a) Carbon and Galvanized Steel: ASME B16.9, seamless weld conforming to ASTM A234.
b) Wrought Stainless Steel: ASME B16.9, seamless weld conforming to ASTM A403.

6. Solder-Joint: Wrought-copper, ASME B16.22, streamlined pattern.
7. Brazed-Joint: Wrought-copper, ASME B16.50, streamlined pattern.
8. Transition Fittings for plastic to metal piping shall be of the plastic material of the adjoining pipe, one-piece, with a threaded brass or copper insert and schedule 80 solvent cement or fusion end.

F. Joining Materials:

4. Reference Division 23 Section "Basic Piping Materials and Methods" for basic joining materials.

2.02 PRE-INSULATED PIPING SYSTEM, BURIED

A. Manufacturers

1. Insul-Tek Piping Systems, Inc.
2. ISCO Industries.
3. Perma-Pipe, Inc.
4. Rovanco Piping Systems, Inc.
5. Thermacor Process, L. P.
6. Tricon Piping Systems, Inc.
7. Urecon Pre-Insulated Pipe

B. Conduit Pipe Pre-Insulated System:

1. Description: Factory-fabricated, watertight, drainable, pressure-tested conduit piping system with internal carrier pipe, pipe supports, and insulation.
2. Carrier Pipe: As specified for the buried hydronic system in Part 3.
3. Carrier Pipe Insulation:

    a) Mineral-Wool (Fiberglass): ASTM C547, Type I or II, Grade A.
    b) Calcium Silicate: ASTM C533, Type I.
    c) Polyisocyanurate: ASTM C591, unfaced.
    d) Polyurethane: ASTM C591, unfaced.

4. Carrier Pipe Support Spacer: Corrugated galvanized steel with a maximum spacing of 10 feet.

    a) Carrier pipe support shall provide the following minimum clearances:

        1) Between carrier pipe insulation and conduit, 1-inch.
        2) Between insulation of multiple carrier pipes, 3/16 inch.
        3) Between bottom of uninsulated carrier pipe and casing, 1-3/8 inches.

5. Conduit Pipe:

    a) Material: ASTM D3350 HDPE, with outside dimensions and wall thickness per ASTM D3035 or D2447.
    b) Fittings: Factory-fabricated and -insulated elbows and tees compatible with the carrier pipe. Elbows may be bent pipe equal to carrier pipe.
    c) Joints: Half-shell kits, with pourable or split insulation, casing sleeve, and shrink wrap sleeve.
    d) Expansion Compensation: Size conduit at offsets with additional clearance required to contain piping expansion.

6. Accessories:

    a) Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches deep and 2 inches larger than conduit; terminate casing 20 inches above the floor level.
    b) Guides and Anchors: Steel plate welded to carrier pipes, complete with vent and drainage openings inside casing.
    c) End Seals: Steel plate welded to carrier pipes, complete with drain and vent openings on vertical centerline.
    d) Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of conduit, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.

C. Cased Pipe Pre-Insulated System:

1. Description: Factory-fabricated, watertight, drainable, cased piping system with internal carrier pipe and insulation.
2. Carrier Pipe: As specified for the buried hydronic system in Part 3.
3. Carrier Pipe Insulation:

    a) Polyurethane: Unfaced, preformed, rigid cellular polyurethane material intended for use as thermal insulation, conforming to ASTM C591.

4. Casing:

    a) Material: ASTM D3350 HDPE, with minimum wall thickness as specified:

        1) Jacket size less than or equal to 12”: 100 mils.
        2) Jacket sizes 12" to 24”: 125 mils.
        3) Jacket sizes larger than 24”: 150 mils.

    b) Fittings: Factory-fabricated and -insulated elbows and tees compatible with the carrier pipe. Elbows may be bent pipe equal to carrier pipe.
    c) Joints: Half-shell kits, with pourable or split insulation, casing sleeve, and shrink wrap sleeve.
    d) Expansion Compensation: Provide expansion cushions external to the system or elastomeric foam insulation blanket internal to the casing, formed to fit over carrier pipe and sized to accommodate the thermal expansion.

5. Accessories:

    a) Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches deep and 2 inches larger than conduit; terminate casing 20 inches above the floor level.
    b) Guides and Anchors: Steel plate welded to carrier pipes, complete with vent and drainage openings inside casing.

c) End Seals: Insulated and sealed watertight around casing and carrier pipe.

d) Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of conduit, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.

2.03 EXPANSION CUSHIONS

A. Flexible Elastomeric Insulation: ASTM C534, Type I, with water absorption of 0.2 percent by volume and density of 4.0 lbs/cu.ft, suitable for direct buried applications.

B. Mineral Fiber (Fiberglass) Insulation: ASTM C547, Type I, with density between 3 to 6 lbs/cu.ft, with temperature rating that exceeds the design operating temperature of the fluid in the piping system it is protecting.

C. Manufacturers:

1. Flexible Elastomeric Insulation:

a) Aeroflex USA.
b) Armacell.e
c) K-Flex USA.
d) Nomaco.

2. Mineral Fiber Insulation:

a) Certainteed.
b) Johns Manville.
c) Knauf.

2.04 MANHOLES

A. General: Black steel with lifting eyes.

B. Finish: Spray-applied urethane, minimum 30 mils thick.

C. Access: 30-inch- diameter waterproof cover with gasket, ladder, and two 6-inch vents, one high and one low, extending above grade with rain caps.

D. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.

E. Sump: 12 inches in diameter, 12 inches deep.

F. Floatation Anchor: Oversized bottom keyed into concrete base.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Install piping to ASME B31.9 requirements.

C. Coordinate the location of underground piping systems with other underground utilities.

D. Do not install underground piping when bedding is wet or frozen.

B. Reference Division 23 Section "Basic Piping Materials and Methods" for general piping installation requirements.

E. Provide manholes where access to the underground piping system is needed.

3.02 EARTHWORK

A. See Division 31 Section "Earth Moving" for excavation, trenching, and backfilling.

B. Reference Division 23 Section, "General Mechanical Requirements" for additional excavation, trenching, and backfilling requirements.

3.03 PIPE APPLICATION SCHEDULE

A. Heating Hot Water Piping:

1. Acceptable Carrier Pipe Materials:

   a) Schedule 40 carbon or galvanized steel with threaded fittings for pipes 2 inch and smaller, and welded or flanged fittings for pipes 2-1/2 inch and larger.

      1) Provide galvanized steel pipe in direct-bury applications.

   b) Stainless steel with threaded fittings for pipes 2 inch and smaller, and welded or flanged fittings for pipes 2-1/2 inch and larger.
   c) Type K copper with soldered, brazed, or flanged fittings.
   d) Flanged fittings are only acceptable in direct-bury applications.

2. Fitting Pressure Class: Minimum rating of 150 psig.
2. Acceptable Bury Methods:

   a) Conduit pipe pre-insulated system.
   b) Cased pipe pre-insulated system.

3. Insulation Thickness:

   a) Pre-Insulated Piping Systems: 1 inch.

B. Chilled Water Piping:

3. Acceptable Carrier Pipe Materials:

   a) Schedule 40 carbon or galvanized steel with threaded fittings for pipes 2 inch and smaller, and welded or flanged fittings for pipes 2-1/2 inch and larger.

      1) Provide galvanized steel pipe in direct-bury applications.

   b) Stainless steel with threaded fittings for pipes 2 inch and smaller, and welded or flanged fittings for pipes 2-1/2 inch and larger.
   c) Type K copper with soldered, brazed, or flanged fittings.
   d) Flanged fittings are only acceptable in direct-bury applications.

4. Fitting Pressure Class: Minimum rating of 150 psig.

2. Acceptable Bury Methods:

   a) Conduit pipe pre-insulated system.
   b) Cased pipe pre-insulated system.

3. Insulation Thickness:

   a) Pre-Insulated Piping Systems: 1 inch.

3.04 EXPANSION CUSHION APPLICATION

A. Direct Buried Piping: For direct buried piping, use flexible elastomeric insulation.

B. Loose Fill Insulation: For piping buried in loose fill insulation, use flexible elastomeric or mineral fiber insulation.

3.05 PREPARATION

A. Preparation of foundation for below ground water distribution pipe and fittings

   1. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.
   2. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.
   3. Pipe Beds for Pre-Insulated Piping Systems or Uninsulated direct-buried piping:

      a) Provide 6 inch thick sand pipe bed underneath and around sides of pipe, up to middle half of the pipe, including fittings. Tamp bed with mechanical tamper to 85 to 95 percent compaction. Provide first layer of sand backfill 6 inches above pipe, tamp backfill with mechanical tamper to 85 to 95 percent compaction.
      b) For piping with rock trench bottoms, provide sand pipe bed 6 inches underneath and around sides of pipe, including fittings.
      c) Provide backfill above top of pipe bed as required for field conditions.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

C. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

D. Remove scale and dirt on inside and outside before assembly.

E. Prepare piping connections to equipment using jointing system specified.

F. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.06 PIPING INSTALLATIONS

A. Remove standing water in the bottom of trench.

B. Do not backfill piping trench until field quality-control testing has been completed and results approved.

C. Maintain 6 inches clearance from obstructions and provide thrust blocks at every branch connection and change in direction.

D. Provide long radius elbows with a minimum centerline radius of 1-1/2 times the pipe diameter. Short radius elbows with a minimum centerline radius of 1 times the pipe diameter may be used only where space does not permit the long radius elbows.

E. Install piping at uniform grade of 1 inch in 40 feet upward in the direction of flow.

F. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

G. Install branch connections to mains using Tee fittings in main with take-off out the top or side of the main unless otherwise shown on the drawings. Up-feed risers shall have take-off out the top of the main line.

1. Tee-drilling is prohibited as a means for connecting branch taps into any main.
2. Bull-head tees are prohibited. Do not install tee fittings in such a way that the flow through the branch leg equals the sum of the flows through the two main legs.

H. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."

I. See Division 26 Section "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.

3.07 PIPE JOINT CONSTRUCTION

C. Reference Division 23 Section, “Basic Piping Materials and Methods” for basic pipe joint construction.

D. Reference Division 23 Section, “Expansion Fittings and Loops for HVAC Piping” for installation of anchors and expansion joints.

A. Where more than one pipe material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.

B. Install non-conductive dielectric connections whenever joining dissimilar metals. Reference Section 230510 Basic Piping Materials and Methods.

C. Pipe-to-Valve and Pipe-to-Equipment Connection: Install flanges or unions between piping and valves and equipment for servicing. Do not use direct welded, brazed, or soldered connections unless specifically called for in the manufacturer’s installation instructions.

D. Fusion Joints: Fuse joints in accordance with ASTM F2620.

E. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.08 EXPANSION CUSHION INSTALLATION

A. General: Install expansion cushions at expansion joints or elbows in accordance with manufacturer’s installation instructions. Provide thickness of cushion in single or multiple layers as required by the manufacturer to absorb the expansion of the piping.

B. Flexible Elastomeric: Provide layers of flexible elastomeric insulation to absorb the pipe expansion. Length of each layer on each side of the elbow shall be as needed to absorb the expansion along the pipe. Refer to manufacturer’s recommendations. Secure the insulation layers to the pipe with fiber reinforced tape or plastic straps.

C. Mineral Wool: Wrap mineral fiber cushion around pipe elbows at changes of direction and at expansion loops. Ensure there is sufficient space or flexibility between cushions to allow loose fill insulation to pour and consolidate under and around the piping. Secure cushion to the pipe with fiber reinforced tape.

3.09 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground piping. Locate tapes 6 to 8 inches below finished grade, directly over piping. See Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.

3.010 FIELD QUALITY CONTROL

A. Reference Division 23 Section “Hydronic Piping” for additional Field Quality Control requirements for carrier pipe testing and flushing.

B. Pressure Testing of Conduit Pipe Pre-Insulated System:

    1. Seal vents and drains and subject conduit to 15 psig for four hours with no loss of pressure. Repair leaks and retest as required.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

3.011 ADJUSTING AND CLEANING

A. Reference Division 23 Section, “Hydronic Piping” for additional Adjusting and Cleaning requirements.

3.012 STARTUP

A. Reference Division 23 Section, “Hydronic Piping” for startup requirements.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Mechanically joined piping system requirements.

B. Carbon steel grooved piping system.

C. Copper grooved piping system.

D. Stainless steel grooved piping system.

E. Copper press-fit piping system.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.

A. Reference Division 23 Section, “Basic Piping Materials and Methods” for additional submittal requirements.

B. Shop Drawings:

1. Indicate grooved-joint couplings and fittings on drawings and product submittals, and specifically identify with the applicable style or series designation.
2. If an assembly of flexible couplings are used for seismic vibration, thermal expansion, or noise and vibration reduction, submit shop drawings indicating location of assembly, including anchors and guides. Include movement analysis of the assembly, and performance data of the assembly.

C. Reports as specified in Part 3 of this Section.

1.04 QUALITY ASSURANCE

B. Comply with Division 23 Section, “Basic Piping Materials and Methods.”

A. Single Source Responsibility: All components of each mechanically joined piping system used shall be of one manufacturer and conform to local code approval.

B. Grooving and Joining Tools: Approved by the mechanically joined piping system manufacturer for use with their system and furnished by one manufacturer, though not necessarily the same as the grooved component manufacturer.

C. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this Section, with minimum three years of documented experience and ISO 9001 certification.

1. Date stamp all castings used for coupling housings, fittings, etc. for quality assurance and traceability.

D. Installer Qualifications:

1. Company specializing in performing work of the type specified in this Section, with minimum three years of documented experience.
2. Certified by the mechanically joined manufacturer on the proper use of mechanically joining tools and installation of mechanically joined piping products.

E. Pipe, fittings, and specialties shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ASME, and ANSI standards.

1.05 DELIVERY, STORAGE, AND HANDLING

C. Comply with Division 23 Section "Basic Piping Materials and Methods."

<u>PART 2 - PRODUCTS</u>

2.01 MECHANICALLY JOINED PIPING SYSTEM REQUIREMENTS

D. Antifreeze and Water Treatment:

1. Refer to Division 23 Section "HVAC Water Treatment" for antifreeze and water treatment products.

A. Pipe Materials:

1. Refer to the specific product sections in Part 2 for the acceptable pipe materials.

B. Fittings:

1. General: Fittings shall be of wall thickness, pressure rating, and material compatible with adjoining pipe as listed and approved by the manufacturer's current literature for the piping system used.
2. Reference Division 23 Section "Basic Piping Materials and Methods" for additional fittings.
3. Grooved:

a) All grooved joints shall be full-flow type and conform to AWWA C606 and ASTM F1476.

1) Victaulic Advanced Groove System (AGS) pipe ends are an acceptable alternate.

b) Body Materials:

1) Ductile Iron: Comply with ASTM A536, Grade 65-45-12 or ASTM A395 Grade 65-45-15.
2) Wrought Steel: Comply with ASTM A234, Grade WPB, 0.375 inch wall.
3) Carbon Steel: Comply with ASTM A53, Grade B or ASTM SA352, Grade LCC.
4) Wrought copper: Comply with ASTM B75 Alloy C12200 or ASTM B152 Alloy C1100.
5) Bronze Sand Cast: Comply with ASTM B16.18 and B584 ally UNS C89836.
6) Stainless Steel: Type 304 or 316, conforming to ASTM A240, A312, A351, A403, A743, or A744, Grade CF8M.

c) Coating: Suitable enamel, epoxy, or hot-dipped galvanized according to ASTM A153 to match system requirements.

4. Strapless Outlet Fittings:

a) Pipe Strapless Outlets: 1/2 inch or 3/4 inch NPT outlet for use on 4 inch and larger pipe sizes, rated for 300 psig.

1) Housing: Ductile iron housing conforming to ASTM A536, Grade 65-45-12, painted black.
2) Collar: Hot rolled steel collar conforming to ASTM A569, zinc electroplated to ASTM B633.
3) Bushing: Brass conforming to UNS C37700.
4) Seat/Liner Gasket: Same as Grooved Joint Gasket requirements specified under article "Joining Materials."

5. Test Caps: Ductile iron cap according to ASTM A536, Grade 65-45-12, suitable for use on metallic IPS pipe with integral NPT ball valve, maximum test pressure of 250 psi and maximum test temperature of 110 degrees F. Victaulic T-60 test cap or approved equal.
6. Press-Fit:

a) Press-fit fittings shall include self-contained O-ring seals in the end connections.
b) Body Materials:

1) Stainless Steel: Type 304 or Type 316, conforming to ASTM A240, A312, A351, A743, or A744, Grade CF8M.
2) Wrought Copper: Comply with ASTM B75 Allow C12200 or ASTM B152 Alloy C1100.
3) Cast Copper: Comply with ASTM B584 Alloy C87600 or C84400.

c) End Connections:

1) Threaded: All threads shall conform to ASME B1.20.1.
2) Solder-Joint: Wrought-copper, ASME B16.18 or B16.22, streamlined pattern.
3) Flared Ends: Comply with ASME B16.26.

C. Joining Materials:

1. Reference Division 23 Section “Basic Piping Materials and Methods” for basic joining materials.

1. Joining Tools: Approved by the mechanically joined piping system manufacturer for use with their system.
2. Grooved Couplings: Multi-piece housing attached with bolts and nuts with pressure responsive elastomeric gasket, constructed of material specified under Article “Fittings” above and of the following styles.

   a) Rigid Couplings: Designed with offsetting angle bolt pads to provide a rigid pipe joint to restrict axial or angular movement.
   b) Flexible Couplings: Designed with flat bolt pads to provide a flexible pipe joint and accommodate a limited amount of linear and/or angular movement.
   c) Reducing Couplings: Designed to include a direct pipe reduction on pipe run without additional components and includes steel washer to prevent telescoping of smaller pipe inside the larger pipe during a vertical system assembly.

3. Coupling Bolts: Track-head type and constructed of the one of the following:

   a) Type 304 or 316 stainless steel conforming to ASTM A193, Grade B8/B8M, Class 2 or ASTM F593 and F594, Group 2, Conditions CW.
   b) Heat treated carbon steel conforming to ASTM A183 and A449, zinc electroplated to ASTM B633, with a minimum tensile strength of 110,000 psi.

4. Nuts: Heavy-duty hexagonal type conforming to ASTM A563, Grade B or ASTM A194, Grade 8M.
5. Washers: Flat type, plated carbon steel conforming to ASTM F436 or Type 304 or 316 stainless steel.
6. Grooved-Joint Gaskets:

   a) Molded synthetic rubber (EPDM compound) with central cavity and pressure responsive configuration, integral pipe stop, and complying with ASTM D2000, Grade 2CA615A25B24F17Z.
   b) Gasket Grade: Type “E” for hydronic applications. Coordinate the appropriate gasket grade with the manufacturer for other applications.
   c) Identification: Tagged with the appropriate color code to indicate the application.
   d) Temperature operating range: -30 degrees F to +230 degrees F.

7. Flange Adapters:

   a) Cast-Bronze Flanges: ASME B16.24, raised ground face, bolt holes spot faced.
   b) Wrought Cast-Iron, Forged Steel, and Stainless Steel: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connection, and facing:

      1) Material Group: 1.1.
      2) Facings: Raised face.

   c) Gaskets: ASME B16.21, non-metallic, asbestos free, 1/8 inch thick, full-face for cast-iron flanges and raised-face steel flanges, suitable for chemical, thermal, and dielectric conditions of piping system contents.
   d) Flange bolts and nuts: ASME B18.2.1, hex head carbon steel according to ASTM A307, Grade B.

8. Pipe Transition Adapters:

   a) Constructed of material, size, and end connection to join different pipe materials or joining methods.
   b) Adapter shall be listed according to the manufacturer's literature for the application and joining methods.
   c) Reference Division 23 Section "Basic Piping Materials and Methods" for dielectric fittings.

9. Press Couplings: Single-piece housing with self-contained O-ring seals in the end connections. O-ring seals shall comply with the following:

   a) EPDM compound conforming to ASME B16.51.
   b) Type "E" EPDM compound complying with ASTM D2000, Grade 2CA615A25B24F17Z.
   c) Identification: Tagged with the appropriate color code to indicate the application.
   d) Temperature operating range: -30 degrees F to +230 degrees F.

D. General Duty Valves and Hydronic Specialties:

1. Acceptable manufacturers listed within this specification may have comparable products which comply with the product specifications referenced in the sections below. These products are acceptable provided they meet the specified requirements and are compatible with the piping system. Reference the Valve and Hydronic Specialties Schedule in Part 3 for examples of acceptable products and design intent. Refer to manufacturer's current literature for comparable products, sizes, pressure ratings, and connection methods compatible with the piping system. Products identified by model number are based on available size and pressure ranges from that manufacturer. Products offered by manufacturers with extended ranges are acceptable provided they meet the specified requirements.

2. Reference Division 23 Section "General Duty Valves for HVAC Piping" for general duty valve requirements.
3. Reference Division 23 Section "Hydronic Specialties" for hydronic specialty requirements.

E. Expansion Joints:

1. Reference Division 23 Section "Expansion Fittings and Loops for HVAC" for expansion joint requirements.
2. Select expansion joint and support method in accordance with design conditions and performance data published in manufacturer's literature using the following types:

a) Slip Type: Victaulic Style 150 Mover telescoping slip type or approved equal.
b) Standard Expansion Type: Style 155 expansion joint consisting of a series of flexible couplings joined in tandem or approved equal.

2.02 CARBON STEEL GROOVED PIPING SYSTEM

A. Manufacturers:

1. ASC Engineered Solutions.
2. Shurjoint Piping Products.
3. Victaulic Company of America.

B. Carbon Steel Pipe:

1. NPS 10 inch and Smaller: ASTM A53 or A106, Type E electric-resistance welded or Type S seamless, Grade B, Schedule 40, black steel, plain ends.

2.03 COPPER GROOVED PIPING SYSTEM

A. Manufacturers:

1. ASC Engineered Solutions.
2. Shurjoint Piping Products.
3. Victaulic Company of America.

B. Copper Tubing:

1. Copper Tube Size (CTS), ASTM B88 Type L, hard-drawn.

2.04 STAINLESS STEEL GROOVED PIPING SYSTEM

A. Manufacturers:

1. ASC Engineered Solutions.
2. Shurjoint Piping Products.
3. Victaulic Company of America.

B. Stainless Steel Pipe:

1. NPS 2 inch and Smaller: ASTM A312, Type 304 or 316, Schedule 10S, plain ends.
2. NPS 2-1/2 inch and larger: ASTM A312, Type 304 or 316, Schedule 10S, plain or beveled ends.

2.05 COPPER PRESS-FIT PIPING SYSTEM (CTS)

A. Manufacturers:

1. ASC Engineered Solutions "Gruvlok."
2. Apollo "Xpress".
3. Mueller Streamline PRS.
4. NIBCO, Inc., Press System.
5. Viega, ProPress.

B. Copper Tubing:

1. CTS 3/4 inch through 4 inch: ASTM B88 Type L, hard-drawn.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Install piping to ASME B31.9 requirements.

C. Reference Division 23 Section "Basic Piping Materials and Methods" for general piping installation requirements.

D. Reference Division 23 Section "General Duty Valves for HVAC Piping" for general duty valve installation requirements.

E. Reference Division 23 Section "Hydronic Specialties" for hydronic specialty installation requirements.

3.02 PIPE APPLICATION SCHEDULE

A. Heating Hot Water System:

1. Carbon Steel Grooved: 2 inch and larger.
2. Copper Grooved: 2 inch through 8 inch.
3. Stainless Steel Grooved: 2 inch and larger.
4. Copper Press-Fit: 3/4 inch through 4 inch.
5. Fitting Pressure Class: Minimum rating of 150 psig.

B. Chilled Water system

1. Carbon Steel Grooved: 2 inch and larger.
2. Copper Grooved: 2 inch through 8 inch.

3. Stainless Steel Grooved: 2 inch and larger.
4. Copper Press-Fit: 3/4 inch through 4 inch.
5. Fitting Pressure Class: Minimum rating of 150 psig.

C. Use stainless steel couplings and fittings where design conditions require the use of non-ferrous piping materials for both interior and exterior piping surfaces.

3.03 PREPARATION

A. Remove scale and dirt on inside and outside before assembly.

B. Verify pipe and tube ends are free from indentations, projections, and roll marks in the area from tube end to groove from proper gasket sealing.

C. Prepare piping connections to equipment using jointing system specified.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.04 PIPING INSTALLATIONS

A. Hydronic piping installations shall be installed subject to Division 23 Section "Hydronic Piping" in addition to those requirements specified in this Section.

3.05 PIPE HANGERS AND SUPPORTS APPLICATION

A. Comply with the requirements of Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

3.06 PIPE JOINT CONSTRUCTION

A. Reference Division 23 Section "Basic Piping Materials and Methods" for basic pipe joint construction.

B. Where more than one pipe material is specified, provide joining fittings or pipe transition adapters with appropriate dielectric isolation that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.

C. Grooved Joints:

1. Ream, debur, and clean tube ends and verify they are free from indentations, projections and roll marks in the area from tube end to groove for proper gasket sealing.
2. Roll and cut groove ends in accordance to manufacturer's current listed standards and according to AWWA C606. Use rolls sets designed and intended for use on the appropriate pipe material when grooving pipe.

a) Victaulic Advanced Groove System (AGS) pipe ends are an acceptable alternate. If Victaulic AGS grooved system is used, all couplings, adapters, fittings, and valves shall be compatible with AGS grooved ends.

b) Do not use cut groove ends in copper tubing, roll groove only.

c) Do not use cut groove ends in stainless steel pipe, roll groove only.

3. Verify tolerances of and maintain grooving tool components for duration of grooving processes. Replace grooving tool components that are found out of tolerance with new as required.
4. Flaring of CTS tube ends to IPS dimensions or to accommodate alternate sized couplings is not allowed.
5. Verify the gasket style and elastomeric material (grade) is suitable for the intended service as specified and in combination with any system chemical additives.
6. Reference latest published manufacturer's product data for additional pressure ratings and application information.
7. Reference the latest published of manufacturer's field installation instructions or other included installation instruction prior to attempting assembly.
8. Install gaskets with lubricant suitable for all piping services. Lubricant shall be by one manufacturer.

D. Press-Fit Joints:

1. Install press piping system in accordance with manufacturer's recommendations.
2. Ream, debur, and clean tube ends and verify they are free from indentations, projections, burrs and foreign matter.
3. Install permanent inspection mark on tube.
4. Clean tube and fittings of all dirt and oil. Verify O-ring is in place and free of oil, grease or dirt.
5. Push pipe or tube into fittings with twisting action to all the way to the fitting stop or shoulder.
6. Mark tube with permanent marker to indicate proper tube insertion depth.
7. Verify press tool has correct size jaw set for tube size used.
8. Complete one tool cycle with empty jaw to calibrate tool for each time new jaw is inserted into tool.
9. Squeeze jaw arms to open tool jaws and place jaws around the contour of the fitting. Verify tool is perpendicular to the fitting and depress tool switch.
10. Squeeze jaw open to remove the tool and observe witness mark.
11. Verify crimped fitting connection for misalignment of the copper tube, misalignment of the tool or improper insertion of the tube. If any of these conditions are found cut out the joint and provide a new joint.
12. Maintain minimum distance between joints per the manufacturer's published installation instructions.

E. Stainless Steel to Copper Systems:

1. Stainless steel 4 inch and smaller to copper 2 inches and smaller:

a) Stainless steel reducing tee with 2 inch grooved side outlet.

b) Stainless steel rigid coupling, dielectric waterway adapter and CTS rigid coupling.

c) Contractors Option (in lieu of above) - 2 inch rigid CTS adapter coupling, 2 inch grooved X copper plain adapter (size as required).

2. Stainless steel 6 inch and larger to copper 2 inches and smaller:

   a) Stainless steel tee and welded pipet with 2 inch welded outlet.

   b) 2 inch schedule 40 stainless steel short nipple with grooved and plain ends. Weld nipple to pipet.

   c) Stainless steel rigid coupling, dielectric waterway adapter and CTS rigid coupling.

   d) Contractors Option (in lieu of above) - Stainless steel reducing tee with 2 inch grooved side outlet, 2 inch rigid CTS adapter coupling, 2 inch grooved X copper plain adapter (size as required).

3. Stainless steel 6 inch and larger to copper 2-1/2 inches to 4 inches:

   a) Stainless steel tee or reducing tee with grooved side outlet:

   b) Stainless steel rigid coupling, dielectric waterway adapter and CTS rigid coupling.

   c) Contractors Option (in lieu of above):

      1) Rigid CTS adapter coupling, grooved X copper plain adapter (size as required).

      2) Grooved X stainless steel flange adapter nipple (X = size as required), bronze flange and dielectric flange kit.

4. Stainless steel to copper 6 inches to 8 inches:

   a) Stainless steel tee or reducing tee with grooved side outlet.

   b) Stainless steel rigid coupling.

   c) Grooved X stainless steel flange adapter nipple (X = size as required).

   d) Bronze flange and dielectric flange kit.

F. Dielectric Isolation Requirements: Refer to Division 23 Section “Basic Piping Materials and Methods” for dielectric fittings and their installation requirements. Provide dielectric flanges, flange kits, or dielectric transition couplings for the following joint types:

1. Flange Adapters to Iron, Ductile Iron or Steel Body Valves or Fittings (Except Butterfly Valves): Provide full face gaskets between flanges and adapter flanges. At each bolt, provide steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves on valve and adapter flanges.

2. Flange Adapters to Butterfly Valves in Series with Iron, Ductile Iron or Steel Body Valves or Fittings: At each bolt, provide stainless steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves on adapter flange. Provide stainless steel bolts on butterfly valve flange.

3. Flange Adapters to Butterfly Valves in Copper Tubing: Install flat washers at each bolt on adapter flange. Provide full face gasket only for butterfly valves without integral liner acting as a gasket.
4. Dielectric Transition Couplings: Provide dielectric transition coupling when connecting copper pipe to butterfly valves. Provide dielectric transition coupling when connecting grooved IPS pipe to CTS pipe.

G. Couplings:

1. Install rigid couplings unless noted otherwise.
2. Install flexible couplings at locations required to accommodate expansion and/or vibration isolation.

    a) Install flexible couplings at pumps.
    b) Install flexible couplings at expansion joints.
    c) Install three flexible couplings at mechanical equipment connections for noise and vibration reduction in lieu of flexible connectors if preferred.

3. Install reducing couplings at reductions in pipe size.
4. Install boltless security couplings where noted on the plans.
5. Install press couplings in conjunction with the appropriate press piping system.

H. Flange Adapters:

1. Install flange adapter washers when flange adapters are used against the following surfaces:

    a) Rubber.
    b) Adapting to ANSI/AWWA cast flanges.
    c) Rubber faced lug valves.
    d) Serrated flanged surfaces.

2. Do not install flange adapters for applications that incorporate tie rods for anchoring or on standard grooved-end fittings within 90 degrees of each other.

I. Miscellaneous Connections:

1. Install test caps for temporary use during piping system testing activities. Test caps shall not be permanently installed in the piping system.
2. Test caps may be reused within the maximum test pressure and provided the product remains undamaged. Inspect and verify the suitability for service of all test caps prior to installation and use.
3. Connect test caps to piping system with Victaulic Style 107N or equivalent rigid coupling.
4. Test cap may be used for filling, testing, or draining purposes by connecting to the NPT outlet of the integral ball valve.
5. Install blind flanges with separate means to fill, test, or drain system for testing if test caps are not available from manufacturer.

3.07 VALVE AND HYDRONIC SPECIALTIES SCHEDULE

A. Reference Division 23 Section "General Duty Valves for HVAC Piping" for general duty valve applications.

B. Valve and Hydronic Specialties Schedule: The following schedule references Victaulic model numbers as examples of acceptable products and design intent.

1. Carbon Steel Grooved Piping System:

Valve or Specialty Type	Model/Series Number
Iron Ball Valve	726
Iron Butterfly Valve	761
Iron Swing Check	712
Iron Lift Check	716
Iron Venturi Check	779
Balancing Valve	785 through 789
Coil Kits	799 or 79V
T-Strainer	730
Y-Strainer	732
Suction Diffuser	731

2. Copper Grooved Piping System:

Valve or Specialty Type	Model/Series Number

3. Brass Butterfly Valve 608NStainless Steel Grooved Piping System:

Valve or Specialty Type	Model/Series Number	
Stainless Steel Ball Valve		726S
Stainless Steel Butterfly Valve		461N
Stainless Steel Swing Check		416 or 712S
		P569

4. Copper Press-Fit Piping System:

Valve or Specialty Type	Model/Series Number
Bronze Ball Valve	*Nibco PC585-70-66
Bronze Gate Valve	*Nibco PF111
Bronze Globe Valve	*Nibco PF211
Bronze Swing Check	*Nibco PF413 or PF480

3.08 HYDRONIC SPECIALTIES INSTALLATION

A. Reference Division 23 Section "Hydronic Piping Specialties" for product requirements.

B. Strainers:

1. Provide copper press to connect X screwed NPT adapters for 2 inches and smaller.
2. Provide press to connect adapter flanges for 2-1/2 inches to 4 inches.
3. Provide copper grooved adapter flanges for 2-1/2 inches to 8 inches.

3.09 EXPANSION JOINT INSTALLATION

A. Provide expansion joints where indicated. Expansion joints and their installation requirements are specified in Division 23 Section “Expansion Fittings and Loops for HVAC Piping”.

1. Provide with copper press to connect ends or copper press to connect X screwed NPT adapters for 2 inches and smaller.
2. Provide with copper press to connect ends or press to connect adapter flanges for 2-1/2 inches to 4 inches.
3. Provide copper grooved adapter flanges for 2-1/2 inches to 8 inches.

B. As a contractor’s option and where field conditions allow, provide expansion joints consisting of an assembly of flexible couplings: Fabricated from a combination of couplings and nipples with rolled groove short type “K” or “L” copper tube nipples and flexible CTS couplings. Install with removable ties to hold joint compressed or expanded during piping fabrication. Provide the same gaskets as specified above for rigid couplings. Provide expansion joints of an assembly of flexible couplings with displacement identical expansion joints as indicated.

3.010 EQUIPMENT CONNECTIONS

A. Grooved flexible style couplings may be used at equipment connections where specified for vibration isolation control only.

B. Press to connect joints shall not be provided for equipment connections. Provide flanges, unions, di-electric unions or waterway fittings. Flanges, unions, di-electric unions and waterway fittings are specified in Division 23 Section “Basic Piping Materials and Methods.”

3.011 FIELD QUALITY CONTROL

A. Reference Division 23 Section “Hydronic Piping” for field quality control requirements in addition to those specified herein.

B. The following procedures are paraphrased from the ASME B31.9, code for pressure piping, building services piping.

C. The mechanically joined piping system manufacturer’s factory trained representative shall provide on-site training for contractor’s field personnel in the use of grooving tools and installation of grooved joint products.

D. Installing contractor shall schedule training session at project site for all workers that will be installing or handling the grooved piping system. Submit certification letter along with list of attendees to Engineer of Record within 30-days of mobilization. Include copy of certification letter with closeout documents.

E. Grooved piping supplier shall provide certification training to Contractor without cost and without additional cost to Owner.

F. Provide testing procedures as defined in Division 23 Section "Hydronic Piping" and as specified in grooved mechanical piping manufacturer's installation instructions.

G. The grooved coupling manufacturer's factory trained representative shall periodically visit the jobsite and review the installation to verify that the contractor is following best recommended practices in grooved product installation.

H. Installing contractor shall visually inspect couplings and repair or replace any misaligned couplings and couplings with gaps prior to calling for substantial completion review as defined in Division 23 Section "Common Work Results for HVAC."

3.012 ADJUSTING AND CLEANING

A. Reference Division 23 Section "Hydronic Piping" for adjusting and cleaning procedures.

3.013 STARTUP

A. Reference Division 23 Section "Hydronic Piping" for startup procedures.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Diaphragm/bladder expansion tanks.

B. Air vents.

C. Air separators.

D. Strainers.

E. Suction diffusers.

F. Flexible connectors.

G. Balancing valves.

H. Automatic flow control valves.

I. Radiator valves.

J. Diverting fittings.

K. Relief valves.

L. Combination Piping Packages (Coil Kits).

M. Glycol automatic feed system.

1.02 SUBMITTALS

A. Submit in accordance with Division 01 Submittals and Division 23 General Mechanical Requirements.

B. Product Data: Include rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, component sizes, rough-in requirements, service sizes, and finishes.

1. Balancing Valves and Diverting Fittings: Include flow and pressure drop curves based on manufacturer's testing.

C. Water Filtration System: Include piping layout and assembly drawings of cooling tower basin sweeper systems. Include all dimensions, piping, water jets, couplings, valves, pressure gauges, and other components required to assemble the complete sweeper system inside the cooling tower basin.

D. Certificates:

1. Inspection certificates for pressure vessels for compliance with ASTM and ANSI manufacturing standards.
2. Welders' certificates complying with the requirements specified in Article, "Quality Assurance."

E. Manufacturer's installation instructions.

F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list for inclusion in Operating and Maintenance manual.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Comply with ASME B31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

C. Fabricate and stamp air separators, air and dirt separators, expansion tanks, and buffer tanks to comply with ASME BPVC-VIII-1.

D. Comply with ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

E. Comply with AWWA Standards for governing filter media; American Water Works Association, Current Edition.

F. Hydronic specialties shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.01 DIAPHRAGM/BLADDER EXPANSION TANKS

A. Manufacturers:

1. American Wheatley.
2. Amtrol, Inc.
3. Armstrong Fluid Technology.
4. Bell & Gossett; Xylem.
5. Caleffi.
6. Grundfos.
7. John Wood Co.
8. Patterson Pump Co.
9. Taco, Inc.
10. Wessels.

B. Construction: Closed, welded carbon steel, tested and stamped in accordance with ASME BPVC-VIII-1; with flexible EPDM diaphragm or bladder sealed into tank, cleaned and prime coated; with tappings for installation of accessories.

1. Pressure rating: As scheduled on the drawings.
2. Maximum operating temperature: 240 degrees F.

C. Accessories: Pressure gauge, air charging fitting, and drain fitting.

2.02 AIR VENTS

A. Manufacturers:

1. American Wheatley.
2. Amtrol, Inc.
3. Armstrong International.
4. Bell & Gossett; Xylem.
5. John Wood Company.
6. Nexus Valves.
7. Spirax Sarco.
8. Taco, Inc.

B. Manual Type: Bronze body and nonferrous internal parts; working pressure as defined by the ANSI fitting class of the system, 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8 inch discharge and inlet connections.

C. Automatic Type: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; working pressure as defined by the ANSI fitting class of the system, 240 deg F operating temperature; and having 1/4 inch discharge connection and 1/2 inch inlet connection.

2.03 AIR SEPARATORS

A. Air and Dirt Coalescing Medium Type:

1. Manufacturers:

   a) American Wheatley.
   b) Armstrong Fluid Technology.
   c) Bell & Gossett; Xylem.
   d) Caleffi.
   e) Spirotherm.
   f) Taco, Inc.
   g) Thrush.
   h) Wessels.

2. Construction: Closed, welded steel; tested and stamped according to ASME BPVC-VIII-1; with the bottom of the vessel extended for dirt separation with the system connection nozzles equidistant from the top and bottom of the vessel, and flanged connection or removable cover for access to the internal media for maintenance or cleaning.

   a) Pressure rating: As scheduled on the drawings.
   b) Maximum operating temperature: 270 degrees F.

3. Coalescing Medium: Structured copper or stainless steel medium filling the entire vessel to suppress fluid turbulence and provide air elimination efficiency of 100 percent free air, 100 percent entrained air, and 99.6 percent dissolved air at the installed location.
4. Air Vent: Integral float actuated air vent at the top fitting of tank, threaded to the top of the separator. There shall be no restrictions in the connection from the venting chamber to the vent. Provide side taps with shutoff valve to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill.
5. Inlet and Outlet Connections: Threaded for 2 inch NPS and smaller; flanged connections for 2-1/2 inch NPS and larger.
6. Blowdown Connection: Bottom connection with threaded shutoff valve.
7. Size: Not to exceed 10 feet per second at the scheduled flow rate.

2.04 STRAINERS

A. Manufacturers:

1. American Wheatley.
2. Armstrong International.
3. Hoffman Specialty; Xylem.
4. Keckley.
5. Metraflex Co.
6. Mueller Steam Specialties.
7. Spirax Sarco.
8. Nexus Valve.

9. Watts Water Technologies.

B. Pressure Rating: Rated for working pressure as defined by the ANSI fitting class of the system.

C. Size 2 inch and Smaller:

1. Body: Bronze, ASTM B62 or forged brass ASTM B283.
2. Ends: Threaded.
3. Cover: Screwed.
4. Screen: Type 304 stainless steel with mesh rating based on the Strainer Schedule in Part 3.

D. Size 2-1/2 inch and Larger:

1. Body: Cast iron, ASTM A126 Class B.
2. Ends: Flanged or grooved.
3. Cover: Bolted.
4. Screen: Type 304 stainless steel with mesh rating based on the Strainer Schedule in Part 3.

2.05 SUCTION DIFFUSERS

A. Manufacturers:

1. American Wheatley.
2. Armstrong Fluid Technology.
3. Bell & Gossett; Xylem.
4. Keckley.
5. PACO; Grundfos Pumps Corp.
6. Patterson Pump Co.
7. Taco, Inc.
8. Victaulic.

B. Construction: Angle pattern, cast-iron body, threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger.

1. Pressure Rating: As scheduled on the drawings, minimum working pressure as defined by the ANSI fitting class of the system.
2. Maximum operating temperature: 300 degrees F.

C. Accessories:

1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head. Provide stainless steel strainer in condenser water system.
3. Provide disposable screen (5/32 inch mesh) to fit over cylinder strainer for cleaning during startup procedures.

4. Adjustable foot support, designed to carry weight of suction piping.
5. Blowdown tapping in bottom; gauge tapping in side.

2.06 FLEXIBLE CONNECTORS

A. General: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections.

B. Metal-Type:

1. Manufacturers:

a) American Wheatley.
b) Duraflex.
c) Flex-Hose, Inc.
d) Flexicraft Industries.
e) Flex Pipe USA
f) Hyspan Precision Products.
g) Mason Industries, Inc.
h) Metraflex Co.
i) Twin City Hose.
j) Unaflex, Inc.

2. Construction:

a) Braided Hose: Flanged or threaded to match equipment connection, corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.
b) Bellows: Flanged, stainless-steel bellows with woven, flexible, stainless steel, wire-reinforcing protective jacket.

3. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.
4. Maximum operating temperature: 250 degrees F.
5. Lateral Movement: Capable of accepting 3/4 inch misalignment.

C. Rubber-Type:

1. Manufacturers:

a) American Wheatley.
b) Duraflex.
c) Flex-Hose, Inc.
d) Flexicraft Industries.
e) Flex Pipe USA.
f) General Rubber Corp.
g) Griswold Controls.
h) Hydronic Components Inc.
i) IMI Hydronic Engineering.
j) Mason Industries, Inc.

k) Mercer Rubber Co.
l) Metraflex Co.
m) Nexus Valves
n) Nutech Hydronic Specialty Products
o) Proco Products, Inc.
p) Twin City Hose.
q) Unaflex, Inc.

2. Construction:

a) Braided Hose: Threaded, CPE or EPDM inner tube, stainless steel braid, stainless steel ferrules, brass or steel end connections.
b) Bellows Type: Flanged, fiber-reinforced EPDM rubber body with steel flanges. Do not use control rods.

1) Basis of Design: Mason Industries Type SFDEJ twin sphere connection or equal.

3. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.
4. Maximum operating temperature: 250 degrees F.
5. Lateral Movement: Capable of accepting 3/4 inch misalignment.

2.07 TRIPLE DUTY VALVES

A. Manufacturers:

1. American Wheatley.
2. Armstrong Fluid Technology.
3. Bell & Gossett; Xylem.
4. Keckley.
5. PACO; Grundfos Pumps Corp.
6. Taco, Inc.
7. Watts Water Technologies.

B. Construction: Straight or angle pattern, flanged, cast-iron body with bolt-on bonnet, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

1. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.
2. Maximum operating temperature: 300 degrees F.

2.08 BALANCING VALVES

A. Manufacturers:

1. American Wheatley.
2. Armstrong Fluid Technology.
3. Bell & Gossett; Xylem.
4. Caleffi.

5. Griswold Controls.
6. Hays Fluid Controls.
7. Hydronic Components Inc.
8. IMI Hydronic Engineering.
9. Nexus Valve.
10. Nibco Inc.
11. Nutech Hydronic Specialty Products
12. Oventrop.
13. Pro Hydronic Specialties.
14. Taco, Inc.
15. Victaulic Company of America.

B. Construction: Provide balancing valve with fixed orifice flow balancing, flow measurement, and shut-off capabilities, memory stops, and minimum of two differential pressure metering ports.

1. Quarter Turn: Provide ball or butterfly quarter turn style for measurement use in variable flow applications.
2. Full Turn: Provide plug or globe, full or multiple turn style for balancing use in constant flow applications.
3. Size 2 inch and Smaller: Bronze or forged brass body, threaded connections.
4. Size 2-1/2 inches and Larger: Cast iron, carbon steel, or ductile iron body, with flanged or grooved connections.
5. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.
6. Maximum operating temperature: 250 degrees F.

C. Accessories: Valve shall include integral pointer and calibrated scale to register degree of valve opening, with position indication readout for repeatable regulation and control.

2.09 AUTOMATIC FLOW CONTROL VALVES

A. Manufacturers:

1. Griswold Controls.
2. Hays Fluid Controls.
3. Hydronic Components Inc.
4. IMI Hydronic Engineering.
5. Nexus Valve.
6. Nutech Hydronic Specialty Products.
7. Pro Hydronic Specialties.
8. Victaulic (TA Series).

B. Construction: Bronze or forged brass body with threaded connections for sizes 2 inch and smaller, cast iron or ductile iron body with flanged connections for sizes 2-1/2 inch and larger. Include temperature and pressure test plug on inlet and outlet.

1. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.
2. Maximum operating temperature: 250 degrees F.

C. Calibration: Control flow within 5 percent of selected rating, over minimum pressure 2 psi through 32 psi.

D. Control Mechanism: Provide stainless steel or nickel-plated, brass piston or regulator cup, operating against stainless steel helical or wave formed spring.

E. Accessories: Metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and flow rate in GPM.

2.010 RADIATOR VALVES

A. Manufacturers:

1. Armstrong International.
2. ITT Bell & Gossett.
3. Myson, Inc.
4. Oventrop Corporation.

B. Construction: Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

2.011 DIVERTING FITTINGS

A. Manufacturers:

1. Amtrol, Inc.
2. Armstrong Fluid Technology.
3. Bell & Gossett; Xylem.
4. Taco, Inc.

B. Constructions: Cast iron body with threaded ends or wrought copper with solder ends, rated for 125 psig working pressure, 250 deg F maximum operating temperature. Indicate flow direction on fitting.

2.012 RELIEF VALVES

A. Manufacturers:

1. American Wheatley.
2. Armstrong International.
3. Bell & Gossett; Xylem.
4. Caleffi.
5. Keckley.

6. Spence Engineering Company, Inc.
7. Spirax Sarco.
8. Watts Water Technologies.

B. Safety Relief Valves: Forged brass, bronze, or cast iron, compatible with the piping system, Teflon seat, brass or stainless steel stem, stainless steel springs, EPDM or rubber diaphragm; designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code.

C. Combined Pressure/Temperature Relief Valves: Forged brass, bronze, or cast iron, compatible with the piping system, diaphragm operated, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Provide with fast fill feature for filling hydronic system. Valve shall be factory-set at operating pressure and have the capability for field adjustment; designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code.

D. Pressure Rating: Minimum working pressure as defined by the ANSI fitting class of the system.

E. Maximum operating temperature: 250 degrees F.

F. Opening Pressure and Capacity Setpoint: As scheduled on the drawings.

2.013 PRESSURE REDUCING VALVES

A. Manufacturers:

1. American Wheatley.
2. Armstrong International.
3. Bell & Gossett; Xylem.
4. Caleffi.
5. Keckley.
6. Spence Engineering Company, Inc.
7. Watts Water Technologies.

B. Construction: Valve shall be diaphragm operated, cast-iron or forged brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.

2.014 COMBINATION PIPING PACKAGES (COIL KITS)

A. Combination piping packages are allowed in lieu of individual components specified for hydronic coils and devices containing hydronic coils.

B. Components shall be same size as piping serving the unit as shown on the drawings. Control valves do not need to be same size as piping subject to the sizing requirements set forth in Division 23 "Instrumentation and Control Devices for HVAC."

C. Package shall include the components and shall match layouts specified on the Drawings. Each component of the combination piping package shall meet the specifications for the individual components being combined.

2.015 GLYCOL AUTOMATIC FEED SYSTEM

A. Manufacturers:

1. Bell & Gossett; Xylem.
2. John Wood Company.
3. Wessels Company.

B. General: Provide a packaged, automatic glycol solution make-up unit complete with the following components and accessories:

1. Structural steel base, primed and enamel painted.
2. Minimum 50 gallon polyethylene solution container with removable lid.
3. Solution level scale.
4. Isolation, check and balance valves, strainer, and expansion tank.
5. Provide pump as scheduled on drawings with magnetic starter, 110 volt, 60 Hz motor and controls, and 1/2 inch system connection.
6. Pressure control and interconnecting piping
7. Automatic pump start on falling system pressure
8. Low level cut-off with 110 volt signal for remote alarm

PART 3 - EXECUTION

3.01 HYDRONIC SPECIALTY APPLICATIONS

A. Reference Division 23 Section "General Duty Valves for HVAC Piping" for general duty valve applications.

B. Air Vents:

1. Manual Type: High points in the system outside of mechanical rooms, at heat transfer coils, and elsewhere as required for system air venting.
2. Automatic Type: Air separator outlets, expansion tank connections, high points in outlet piping of boilers and hot water heat exchangers, and elsewhere as required for system air venting within a mechanical room.

C. Strainers: Inlet of each pressure reducing valve, pump, and elsewhere as indicated. Do not install strainers on the inlet of pumps serving open loop condenser water systems. Provide strainers in open loop condenser water system where shown on the drawings.

D. Suction Diffusers: Install on the pump suction inlet. Do not include strainer in suction diffusers installed on pumps serving open condenser water systems, such as cooling towers. Provide strainers in open loop condenser water system where shown on the drawings.

E. Flexible Connectors:

1. Metal Type: Inlet and discharge connections to pumps (unless otherwise indicated) and other vibration producing equipment.
2. Rubber Type: Inlet and discharge connections to pumps (unless otherwise indicated) and other vibration producing equipment.
3. Omit flexible connectors if replaced by series of three grooved couplings on projects where grooved pipe is used.

F. Triple Duty Valves: Contractor has option to provide triple duty valve in the pump discharge line if lieu of balance and check valves. Shutoff valve is still required even if triple duty valve is used.

G. Balancing Valves:

1. Constant Volume Pumping Systems: Where shown on the drawings and elsewhere as required to facilitate system balancing.
2. Variable Volume Pumping Systems: Where shown on the drawings, sized for the smaller of the pipe size or to have a minimum pressure drop of 1 psig at the design flow rate.

H. Automatic Flow Control Valves: Water source heat pumps.

I. Radiator Valves: Water inlet to radiators.

J. Relief Valves: Where located on the plans and at pressure tanks, hot water generators, low pressure side of reducing valves, heat exchangers, and expansion tanks. Install elsewhere as required by ASME Boiler and Pressure Vessel Code.

K. Pressure Reducing Valves: Hot water generators, and elsewhere as required to regulate system pressure.

3.02 STRAINER SCHEDULE

A. Acceptable strainer types based on fluid and pipe size:

1. Hydronic in Pipes Smaller than 4 inch: Y-Type.
2. Hydronic in Pipes Larger than 4 inch: Y-Type, T-Type, Basket.

B. Acceptable strainer types based on orientation:

1. Horizontal: Y-Type, T-Type, Basket.
2. Vertical: Y-Type, T-Type.

C. Screen Mesh Rating Based on Application:

1. General Piping:

    a) Pipe size 4 inch and smaller: 0.062 inches (12 mesh).
    b) Pipe size larger than 4 inch: 0.125 inch (6 mesh).

2. Upstream of automatic flow control valves: 0.0331 inch (20 mesh).
3. Upstream of brazed plate heat exchangers: 0.0331 inch (20 mesh).
4. Upstream of plate and frame heat exchangers: 0.0787 inch (10 mesh).

3.03 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions.

B. Reference Division 23 Section "Basic Piping Materials and Methods" for general piping installation requirements.

C. Expansion Tanks:

1. Diaphragm/Bladder Tanks:

    a) Install diaphragm/bladder-type expansion tanks on floor or support from structure as indicated on the drawings. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements.
    b) Support tank as detailed on the Drawings. In the absence of details, provide support from the floor or structure above, sufficient for the weight of the tank, piping connections, and fittings, plus weight of water assuming a full tank of water. Do not overload building components and structural members.
    c) Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles.

D. Air Vents:

1. Where large air quantities can accumulate, provide enlarged air collection standpipes.
2. Install manual air vents in piping mains with a tee fitting, 1/2 inch ball valve, threaded nipple, and cap.
3. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

E. Air Separators:

1. Install with shutoff valves on the inlet and outlet piping.
2. Install automatic air vent at air outlet and run piping to floor drain.
3. Install in-line air separators with drain valve on units 2 inch and larger.
4. Install combination air and dirt separator blowdown piping with gate valve; extend to nearest drain.
5. Install air and air/dirt separators on floor or support from structure as indicated on the drawings.

6. Support tank as detailed on the Drawings. In the absence of details, provide support from the floor or structure above, sufficient for the weight of the tank, piping connections, and fittings, plus weight of water assuming a full tank of water. Do not overload building components and structural members.

F. Strainers:

1. Provide valved drain and hose connection on strainer blowdown connection for strainers 2 inch and larger.

G. Suction Diffusers:

1. Adjust foot support to carry weight of suction diffuser. Install nipple and ball valve in blowdown connection.

H. Triple Duty Valves:

1. Install triple duty valves with stem in upward position. Allow clearance above stem for check mechanism removal.

I. Relief Valves:

1. Adjust relief valve setpoint as noted on the drawings.
2. Pipe relief valve outlet to nearest floor drain.
3. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

J. Glycol Automatic Feed System.

1. Clean and flush glycol system before adding glycol solution. Perform tests determining strength of glycol and water solution and submit written test results. Reference Section 23 25 00 - HVAC Water Treatment.
2. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

3.04 STARTUP

A. Reference Division 23 Section Hydronic Piping for general startup requirements.

B. Start up and commissioning of water filtration unit shall be performed by a factory authorized representative.

C. Start up and commissioning of glycol makeup unit shall be performed by a factory authorized representative.

D. Remove temporary strainer after cleaning system.

3.05 TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water filtration equipment and/or glycol makeup equipment.

B. Training for Owner’s personnel shall include but not be limited to:

   1. Overview of the system and /or equipment as it relates to the facility as a whole.
   2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.

C. Review manufacturer’s safety data sheets for handling of chemicals.

D. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 and Division 23 Section "General Mechanical Requirements."

E. Schedule at least four hours of training with Owner, through Architect, with at least seven days' advance notice.

F. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Base-mounted, close-coupled end suction pumps.

1.02 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.

C. Millwright's Certificate: Certify that base mounted pumps have been aligned.

D. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.

E. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Pump Seals: 1 for each type and size of pump.
2. Extra Cartridges for Side-Stream Filters: One set for each filter.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum three years of documented experience.

B. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.

C. Product Options: Drawings indicate size, profiles and connections requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

D. Regulatory Requirements: Fabricate and test pumps to comply with HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and HI 1.6, "Centrifugal Pump Tests."

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

1.04 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.05 WARRANTY

A. Warranty on Pumps: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, pumps with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement includes both parts and labor for removal and reinstallation.

   1. Warranty Period: One year from date of substantial completion.

PART 2 - PRODUCTS

2.01 HVAC PUMPS - GENERAL

A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

B. Minimum Quality Standard: .

C. Base Mounted Pumps: Aligned by qualified millwright.

D. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

E. Pumps and Circulators: Factory-assembled and factory-tested. Fabricate casings to allow removal and replacement of impellers without necessity of disconnecting piping. Type, sizes, and capacities shall be as indicated.

F. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles.

G. Motors: Conform to NEMA Standard MG-1, general purpose, continuous duty, Design B, except Design C where required for high starting torque; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal-overload protection, and grease-lubricated ball bearings. Select motors that are non-overloading within the full range of the pump performance curve. Refer to Section "Common Motor Requirements for HVAC Equipment" for additional requirements.

1. Efficiency: Motors shall have a minimum efficiency meeting the requirements of the Energy Policy Act of 1992 as defined in NEMA MG-1 when tested in accordance with IEEE Standard 112, Test Method B.

a) Motor Frame: NEMA Standard 48 or 54; use pump manufacturer's standard.

H. Apply factory finish paint to assembled, tested units prior to shipping.

2.02 BASE-MOUNTED CLOSED-COUPLED, END-SUCTION PUMPS

A. Type: Pumps shall be base-mounted, centrifugal, close-coupled, end-suction, single-stage, bronze-fitted, radially split case design, and rated at 175 psi maximum working pressure and 225 deg F continuous water temperature.

B. Casing: Cast iron with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

C. Impeller: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking capscrew.

D. Bearings: Grease lubricated roller or ball bearings.

E. Shaft: Steel shaft, with bronze sleeve. Provide neoprene slinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

F. Seal: Carbon rotating against a stationary ceramic seat, viton fitted, 225 degrees F maximum continuous operating temperature.

G. Drive: Flexible coupling with coupling guard.

H. Baseplate: Cast iron or fabricated steel with integral drain rim.

I. Manufacturers:

1. American Marsh Pumps.
2. Armstrong Fluid Technology, Inc
3. Aurora Pumps.
4. Bell & Gossett, ITT.
5. Goulds Water Technology
6. Grundfos Pumps Corp.
7. Paco Pumps.
8. Patterson Pump Co.
9. Peerless Pump.
10. Taco, Inc.
11. Thrush Company, Inc.
12. Weinman.

PART 3 - EXECUTION

3.01 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or eccentric reducers installed flat on top. Support piping adjacent to pump such that no weight is carried on pump casings. For Vertical In-line or base-mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.

D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge. A separate strainer is not required if a suction diffuser with strainer is provided.

E. Provide air cock and drain connection on horizontal pump casings.

F. Provide drains for bases and seals, piped to and discharging into floor drains.

G. Install flexible connectors on the suction and discharge side of each pump mounted on housekeeping pad. Install flexible connectors between the pump casing and the discharge valves, and upstream of the pump suction diffuser.

H. Provide vibration isolation for pumps as specified in Section “Vibration Isolation for HVAC”.

I. Install a combination pressure gauge with tubing connected to the suction and discharge of each pump at the integral pressure gauge tappings provided as well as a tap upstream of the suction diffuser and strainer.

J. Install temperature and pressure gauge connector plugs in suction and discharge piping around pump. Temperature and pressure gauge connector plugs are specified in Section "Meters and Gauges."

K. Check, align, and certify alignment of base-mounted pumps prior to start-up. Comply with pump and coupling manufacturer’s written instruction.

L. Install floor mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to the drawings and Section “Vibration Isolation for HVAC” to determine where concrete inertia bases are required.

   1. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute "Centrifugal Pumps - Instructions for Installation, Operation and Maintenance."
   2. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

M. Lubricate pumps before start-up.

3.03 STARTUP

A. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

   1. Lubricate oil-lubricated bearings.
   2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
   3. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
   4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
   5. Clean strainers.
   6. Check piping connections for tightness.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.
2. Open the valve in the cooling water supply to the bearings, where applicable.
3. Open the cooling water supply valve if the stuffing boxes are water-cooled.
4. Open the sealing liquid supply valve if the pump is so fitted.
5. Open the warm-up valve of a pump handling hot liquids if the pump is not normally kept at operating temperature.
6. Open the recirculating line valve if the pump should not be operated against dead shutoff.
7. Start the motor.
8. Open the discharge valve slowly.
9. Observe the leakage from the stuffing boxes and adjust the sealing liquid valve for proper flow to ensure the lubrication of the packing. Do not tighten the gland immediately, but let the packing run in before reducing the leakage through the stuffing boxes.
10. Check the general mechanical operation of the pump and motor.
11. Close the recirculating line valve once there is sufficient flow through the pump to prevent overheating.

C. If the pump is to be started against a closed check valve with the discharge valve open, the steps are the same, except that the discharge valve is opened some time before the motor is started.

D. Retouch any marred or scratched surfaces of factory-finished surfaces, using finish materials furnished by manufacturer.

E. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.04 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of four hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.

3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Chemicals and test equipment.

B. Chemical feeding equipment.

1.02 REFERENCE STANDARDS

A. ASHRAE Guideline 12, Managing the Risk of Legionellosis Associated with Building Water Systems.

B. ASHRAE Standard 188, Legionellosis: Risk Management for Building Water Systems.

C. FM (AG) – FM Approval Guide.

D. ITS (DIR) – Directory of Listed products.

E. UL (DIR) – Online Certifications Directory.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.

B. Product Data: Submit product cutsheets, materials, accessories, chemicals, and equipment, including electrical characteristics and connection requirements, rated capacities, water-pressure drops, shipping, installed, and operating weights for the water treatment system.

C. Shop Drawings: Indicate system schematic, equipment locations, controls schematics, and electrical characteristics. Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

D. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

F. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment to confirm compliance with performance requirements.

G. Certificate: Submit certificate of compliance from Authority Having Jurisdiction indicating approval of chemicals and their proposed disposal.

H. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.

I. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations. Include in maintenance manuals specified in Division 1.

J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

   1. Sufficient chemicals for treatment and testing during required maintenance period.

K. Warranty and maintenance agreement.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

B. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project.

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

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.05 WARRANTY

A. Warranty: Submit written warranty, signed by Manufacturer and countersigned by Installer and Contractor, agreeing to adjust or replace system or portions thereof, as required to achieve required performances, during 1-year period following final start-up for continued operation of condenser water system.

B. Agreement to Maintain: Prior to time of final acceptance, manufacturer of water treatment system shall submit 4 copies of "Agreement for Continued Service and Maintenance" for water treatment system for Owner's possible acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing, and including replacement of materials and equipment, for one-year with option for renewal of Agreement by Owner.

1.06 SPARE PARTS

A. Chemicals, Water Treatment: Furnish 6 month supply of chemicals recommended by water treatment system manufacturer for treating water to meet specified water quality.

1. Ascertain from water piping system Installer, what materials are used for pump seals. Provide only chemicals that are compatible with these materials.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. General: The following manufacturers of water treatment systems are acceptable. Manufacturers shall provide chemical feed equipment that meet the requirements specified herein.

1. AmSolv Total Water Management
2. Aquanomics
3. Kurita
4. MAC Water Technologies
5. Nalco, an Ecolab Company.
6. Suez Water Technologies.

7. Water Treatment Vendor that is listed under Association of Water Technologies (ATW) with a Certified Water Technician (CWT).

2.02 CHEMICALS AND TEST EQUIPMENT

A. General: Furnish chemicals of type and quantity as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment.

B. Antifreeze: Propylene glycol with corrosion inhibitors and environmental-stabilizer additives for mixing with water to protect the hydronic system and connected equipment from physical damage from freezing or corrosion.

C. System Cleaner:

1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
2. For closed systems, provide nonoxidizing biocide treatment if needed to meet biological parameters from water test performed after system is cleaned..

D. Closed System Treatment (Water):

1. Sequestering agent to reduce deposits and adjust Ph.
2. Corrosion inhibitors.
3. Conductivity enhancers.

E. Test Equipment:

1. Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, sodium sulfite for dissolved oxygen, biocount, chloride, and total alkalinity and for calcium hardness field tests.
2. Corrosion Test Coupon Assembly: Constructed of corrosion material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.

   a) Two station rack for closed-loop systems.
   b) Four station rack for open condenser water systems.

2.03 CHEMICAL FEEDING EQUIPMENT

A. Bypass (Pot) Feeder: Cast iron or steel, for introducing chemicals into system; with funnel shutoff valve on top, air-release valve on top, drain valve on bottom, and recirculating shutoff valves on sides.

1. Capacity: 5 gal. for working pressure of 150 psig.

PART 3 - EXECUTION

3.01 PERFORMANCE REQUIREMENTS

A. Provide a water treatment system sized and equipped to treat raw make-up water available at project site.

B. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

C. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

D. Coordinate the use of oxidizing agents supplemented with non-oxidizers sequentially to ensure organisms do not become immune to treatment per ASHRAE Guideline 12-2000.

E. Except as otherwise indicated, provide water treatment system manufacturer's standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.

F. Comply with applicable codes for addition of non-potable chemicals to building mechanical systems and to public sewage systems.

G. Perform work in accordance with local health department regulations.

3.02 PREPARATION

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified.

B. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

C. Place terminal control valves in open position during cleaning.

D. Verify that electric power is available and of the correct characteristics.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install treatment equipment level and plumb.

C. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

E. Electrical Coordination:

1. Coordinate applicable electrical requirements in Division 26 sections for connecting and grounding electrical equipment.
2. Coordinate electrical connectors and terminals are tightened according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 CLOSED SYSTEM TREATMENT

A. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.

B. Introduce closed system treatment through bypass feeder when required or indicated by test.

C. Provide 3/4 inch water coupon rack around circulating pumps with space for 2 test specimens.

3.05 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

B. Test chemical feed piping as follows:

1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
2. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
5. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
6. Prepare test reports, including required corrective action.

C. Fluid Testing:

1. Coordinate with the testing requirements specified in Division 23 Section “Hydronic Piping”

3.06 ADJUSTING

A. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare certified test report for each required water performance characteristic. Where applicable, comply with ASTM D 3370 and the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

B. Occupancy Adjustments: Within 12 months of Substantial Completion, perform two separate water analyses to prove that automatic chemical feed systems are maintaining water quality within performance requirements specified in this Section. Perform analyses at least 60 days apart. Submit written reports of water analysis.

3.07 CLOSEOUT ACTIVITIES

A. Training: Train Owner’s personnel on operation and maintenance of chemical treatment system.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

C. Provide overview of the system and /or equipment as it relates to the facility as a whole.

D. Review operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.

E. Review manufacturer's safety data sheets for handling of chemicals.

F. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 and Division 23 Section "General Mechanical Requirements."

G. Provide minimum of two hours of training with Owner with at least seven days advance notice.

H. Have operation and maintenance data prepared and available for review during training.

I. Conduct training using actual equipment after treated system has been put into full operation.

J. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner’s designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner’s representative indicating agreement that the training has been provided.

K. Submit certificate of compliance from Authority Having Jurisdiction indicating approval of installation.

3.08 MAINTENANCE

A. Provide a separate maintenance contract for specified maintenance service.

B. Perform maintenance work using competent and qualified personnel under the supervision and in the direct employ of the equipment manufacturer or original installer.

C. Maintenance service shall not be assigned or transferred to any agent or subcontractor without prior written consent of Owner.

D. Provide monthly technical service visits to perform field inspections and make water analysis on-site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.

E. Provide laboratory and technical assistance services during this maintenance period.

F. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

G. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

END OF SECTION

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PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes:

1. Metal ductwork.
2. Duct liner.
3. Duct sealants.
4. Duct hangers and supports.
5. Wire rope hanging system.
6. Manufactured ductwork and fittings.
7. Factory-fabricated grease exhaust ductwork.
8. Snap-Lock duct system.

1.02 REFERENCE STANDARDS

A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.

B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

C. ASTM A90 - Standard Specification for Weight [Mass] of Coating on Iron and Steel Articles with Zinc of Zinc-Alloy Coatings.

D. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

E. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

F. ASTM A700 - Standard Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment.

G. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.

H. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

I. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

J. ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

K. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

L. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

N. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

O. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

P. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems, 2013

Q. AWS D1.1 - Structural Welding Code - Steel

R. AWS D9.1 - Sheet Metal Welding Code

S. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.

T. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.

U. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

V. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

W. NADCA ACR-2002 - Assessment, Cleaning & Restoration of HVAC Systems; National Air Duct Cleaners Association

X. NAIMA - Duct Cleaning Guide; North American Insulation Manufacturers Association

Y. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

Z. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

AA. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

BB. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

CC. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines.

DD. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.

EE. TIMA AHC-101; Thermal Insulation Manufacturers Association

FF. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.

GG. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

HH. UL 1978 - Grease Ducts; Current Edition, Including All Revisions.

II. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

1.03 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.

2. Joints: Joints include girth joints; branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.04 SYSTEM PERFORMANCE REQUIREMENTS

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

1.05 SUBMITTALS

A. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

1. Duct Liner.
2. Sealing Materials.
3. Fire-Stopping Materials.
4. Duct Cleaning Products.

B. Shop drawings from duct fabrication shop, drawn to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as the Contract Drawings, detailing:

1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.
2. Duct layout, indicating pressure classifications, duct gauge and sizes in plan view. For exhaust ducts systems, indicate the classification of the materials handled as defined in this Section.
3. Fittings.
4. Reinforcing details and spacing.
5. Seam and joint construction details.
6. Penetrations through fire-rated and other partitions.
7. Terminal heating and cooling unit, coil, humidifier and duct silencer installations.
8. Locations of fire and fire/smoke dampers and associated duct access doors.
9. Locations of cleanout and access doors in grease exhaust ducts.
10. Location of manual balancing dampers.
11. Duct smoke detector locations. Refer to electrical drawings for general locations and coordinate locations with the electrical contractor.

12. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

C. Coordination drawings for ductwork installation in accordance with Division 23 Section "General Mechanical Requirements." In addition to the requirements specified in "General Mechanical Requirements" show the following:

1. Coordination with ceiling suspension members.
2. Spatial coordination with other systems installed in the same space with the duct systems.
3. Coordination of ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
4. Coordination with ceiling-mounted lighting fixtures and air outlets and inlets.

D. Leak Test certificate for all grease duct joints and fittings in compliance with the locally adopted IMC.

E. Record drawings including duct systems routing, fittings details, reinforcing, support, and installed accessories and devices, in accordance with Division 23 Section "General Mechanical Requirements" and Division 1.

F. Welding certificates including welding procedures specifications, welding procedures qualifications test records, and welders' qualifications test records complying with requirements specified in "Quality Assurance" below.

G. Duct Cleaning Plan: Submit written work plan including the following information:

1. Scope of work identifying components that will be cleaned.
2. Identify specific environmental engineering controls required for area of work.
3. Detail the cleaning work means and methods.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of documented experience.

C. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel" for hangers and supports and AWS D9.1 "Sheet Metal Welding Code."

D. Qualify each welder in accordance with AWS qualification tests for welding processes involved. Certify that their qualification is current.

E. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems," except as indicated otherwise.
2. NFPA 90B, "Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
3. NFPA 96, "Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors for Commercial Cooking Equipment," Chapter 3, "Duct System," for kitchen hood duct systems, except as indicated otherwise.

F. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Provide ductwork systems in conformance with "HVAC Duct Construction Standards – Metal and Flexible," latest edition.

G. Underwriter's Laboratories (UL): Comply with the UL standards listed within this section. Provide mastic and tapes that are listed and labeled in accordance with UL 181A and marked according to type.

H. National Air Duct Cleaners Association, Inc. (NADCA): Clean ductwork systems in accordance with the standard Assessment, Cleaning and Restoration of HVAC Systems (ACR 2002).

1.07 PROTECTION AND REPLACEMENT

A. Protect ductwork during shipping and storage from dirt, debris and moisture damage. Provide plastic covers over ends of ductwork during shipping, storage and installation.

B. Replace duct liner that is damaged and cannot be repaired satisfactorily, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation. Drying the insulation is not acceptable. Dry surfaces prior to installing new duct liner.

1.08 FIELD CONDITIONS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 - PRODUCTS AND MATERIALS

2.01 DUCT ASSEMBLIES

A. Ducts: Galvanized steel, unless otherwise indicated. Provide sheet metal in thickness indicated (minimum 26 gauge), packaged and marked as specified in ASTM A700.

B. Primary Supply Air Ducts (upstream of terminal boxes in multizone VAV systems): 4 inches water gauge.

C. Secondary Supply Air Ducts (downstream of terminal boxes in multizone VAV systems): 2 inches water gauge

D. Return and Relief: 2 inch w.g. pressure class, galvanized steel.

E. General Exhaust: 2 inch w.g. pressure class, galvanized steel.

F. Dishwasher Hood Exhaust Ducts: 2 inch w.g. pressure class.

1. Type 304, stainless steel, minimum 18 gauge, with finish to match kitchen equipment and range hood. Provide continuously welded seams on top or sides of duct and flanged joints with watertight EPDM gaskets.
2. Aluminum, with longitudinal seams and laps arranged on top of duct. Seal joints with silicone sealant to provide watertight joint.

G. Type I (Grease) Hood Exhaust Ducts: 2 inch w.g. pressure class, comply with NFPA 96.

1. Concealed: Carbon-steel sheet, minimum 16 gauge.
2. Exposed:

a) Interior to the Building: Type 304, stainless steel, minimum 18 gauge, with finish to match kitchen equipment and range hood.

b) Exterior to the Building:

1) Type 304, stainless steel, minimum 18 gauge.
2) Carbon-steel sheet, minimum 16 gauge, coated with an exterior rated, high temperature corrosion resistant paint.

3. Weld and flange seams and joints.
4. At Contractor's option, a UL listed concentric ductwork package may be used in lieu of the welded carbon or stainless steel duct for connecting hood to exhaust fan. Provide manufacturers UL listing number and verification certificate as a part of the shop drawing submittal. Install duct package in strict conformance with manufacturer's instructions and recommendations.

H. Outside Air Intake: 2 inch w.g. pressure class, galvanized steel.

I. Combustion Air: 2 inch w.g. pressure class, galvanized steel, aluminum or stainless steel.

J. Transfer Air and Sound Boots: 1/2 inch wg pressure class, galvanized steel.

K. Exterior Ductwork: Ductwork installed exterior to the building shall be minimum #18 gauge with longitudinal and transverse joints welded or sealed airtight as specified under Paragraph “Seam and Joint Sealing”.

L. Duct Liner Application: Provide duct liner on the following interior air ducts and where specified on the drawings.

1. Supply Ductwork:

a) Exposed rectangular ductwork.
b) Exposed round ductwork.
c) Above open slat ceiling ductwork.
d) First 50 feet of ductwork downstream of equipment outlets.

2. Return Ductwork.

a) Exposed rectangular ductwork.
b) Exposed round ductwork.
c) Above open slat ceiling ductwork
d) First 50 feet of ductwork upstream of equipment outlets.

2.02 MATERIALS

A. Sheet Metal, General: Provide sheet metal in thickness indicated (minimum 26 gauge), packaged and marked as specified in ASTM A 700.

B. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, lock-forming quality with G90/Z275 coating.. Provide mill phosphatized or galvanized finish for surfaces of ducts exposed to view that is to be field painted. Provide bright galvanized finish for ductwork that is exposed to view and not field painted.

C. Carbon Steel for Ducts: ASTM A1008/A1008M, Designation CS (commercial steel), cold-rolled, with oiled, exposed matte finish.

D. Aluminum for Ducts: ASTM B209 (ASTM B209M); aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength, with standard, one-side bright finish where ducts are exposed to view, and mill finish for concealed ducts.

E. Stainless Steel for Ducts: ASTM A 480, Type 316, with No. 4 finish on exposed surface for ducts exposed to view; Type 304, sheet form, with No. 1 finish for concealed ducts.

F. PVC-Coated Galvanized Steel: UL-181 Class 1 Listing. Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, lock-forming quality with G90/Z275 coating. Provide with factory-applied, 4-mil, PVC coating on exterior of ducts and fittings for underground applications, and the interior of ducts and fittings for fume-handing applications and 2-mil PVC coating on the reverse side of the ducts and fittings.

G. Duct Liner

1. General:

a) Comply with NFPA Standard 90A and North American Insulation Manufacturers Association (NAIMA) Standard AHC-101.
b) Liner shall have a flame spread rating of not more than 25 without evidence of continued progressive combustion and a smoke developed rating of no higher than 50, when tested in accordance with ASTM E84 or UL 723.
c) Duct sizes on mechanical plans indicate clear inside airflow dimensions. Sheet metal sizes for ductwork with duct liner shall be increased accordingly to account for liner thickness.

2. Fiberglass: ASTM C1071, Type I or II, glass fibers firmly bonded together with a thermosetting resin with surface exposed to airstream coated to prevent erosion of glass fibers. Liner surface shall serve as a barrier against infiltration of dust and dirt, shall meet ASTM C 1338 for fungi resistance and shall be cleanable using duct cleaning methods and equipment outlined

by NAIMA Duct Cleaning Guide. Duct liner shall be rated for air velocity of 6,000 fpm.

a) Rectangular fiberglass duct liner shall be Certainteed ToughGard T, JohnsManville Linacoustic RC, Knauf Atmosphere, Owens Corning QuietR or approved equal.

   1) Thickness and Density:

      a) 1 inch, 1-1/2 pounds per cubic foot.

b) Round fiberglass duct liner shall be Certainteed ToughGard UltraRound, JohnsManville Spiracoustic Plus, Owens Corning QuietZone Spiral, or approved equal.

   1) Thickness and Density:

      a) 1 inch, 4 pound per cubic foot.

c) Thermal Performance: Meet minimum "K-Factor" equal to 0.28 (Btu·in/h·sq ft·F) or better, at a mean temperature of 75°F and rated in installed condition in accordance with ASTM C518 and/or ASTM C177.

d) Noise Reduction Coefficient (NRC): Meet the following minimum NRC in accordance with ASTM C423 Type A Mounting:

   1) 1 Inch Thick: NRC 0.65.

e) Liner Adhesive: Comply with NFPA Standard 90A /UL 181 classified with flame spread/smoke development less than 25/50 and ASTM C 916. Adhesive shall be a minimum 50% solid content, water-based, non-oxidizing and have a service temperature of –20 to 200 F. Water-based adhesive shall be one of the following:

   1) Armacell LLC Armaflex 520 BLV low VOC.
   2) Design Polymerics DP 2502.
   3) Duro Dyne WIT.
   4) Foster 85-60.
   5) Childers CP-127.
   6) Johns Manville SuperSeal HV.
   7) Hardcast 951.
   8) United McGill Uni-Tack.

f) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.

   1) Fastener Pin Length: As required for thickness of insulation, and without projecting more than 1/8 inch into the airstream.

2) Adhesive For Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

3. Flexible Elastomeric Acoustical and Conformable Duct Liner: Compliance with ASTM C 534 Grade 1, Type II or ASTM C 1534, NFPA 90A or NFPA 90B, Thickness: 1/2 inch and 1 inch, Thermal Conductivity: 0.25 BTU-in/hr sq ft F at 75 F mean temp, ASTM C 518, Noise Reduction Coefficient: 0.6, ASTM C 423, Sound Transmission Class (STC) 25, ASTM E 90, EPA registered anti-microbial additive to inhibit mold and mildew, ASTM G21.

a) Manufacturers:

1) Aeroflex USA, Inc PLUS Acoustical Duct Liner.
2) Armacell LLC, AP Coilflex.
3) Approved equal.

4. Polyester Duct Liner: Duct liner shall be an engineered nonwoven, thermally bonded polyester with a smooth and durable FSK facing. Liner shall have a noise reduction coefficient of at least 0.65 per ASTM C423 and have thermal values greater or equal to an R-5 at 1 inch, R-6 at 1-1/2 inch and R-8 at 2 inch, respectively. Polyester liner must be able to withstand a constant internal temperature up to 250 F, must be compliant with Greenguard Environmental Institute, and contain zero VOCs per ASTM D5116. Liner must comply with NFPA 90A, NFPA 90 B and UL 181. Liner must meet ASTM C518 for thermal conductance properties and ASTM G-21 for fungal resistance properties. Liner must consist of at least 25 percent recycled content.

a) Manufacturers:

1) Ductmate Industries “PolyArmor.”
2) Approved equal.

H. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.

1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
2. Surface Burning Characteristics: Sealants shall be ASTM E84 or UL 723 listed with a flame spread index not more than 25 and a smoke-developed index not more than 50.
3. For Use with Flexible Ducts: UL labeled.
4. The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics. Duct tape shall not be used as a sealant on any ducts.
5. Joint and Seam Tape: 2 inches wide, glass-fiber-reinforced fabric.

6. Tape Sealing System: Woven-fiber tape impregnated with a gypsum mineral compound and a modified acrylic/silicone activator to react exothermically with the tape to form a hard, durable, airtight seal.
7. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant complying with FS TT-S-001657, Type I; formulated with a minimum of 70 percent solids. Approved products: Childers CP-140, Duro Dyne SGD, Fosters 32-14, or approved equal.
8. Water-Based Joint and Seam Sealant: Non-Fibrated: UL 181 listed. Sealant shall be rated to ±15 inches w.g. Sealant shall have a service temperature of –25 to 200 F and be freeze/thaw stable through 5 cycles. Approved products: Childers CP-146, Design Polymerics DP 1010, Ductmate Proseal/Fiberseal, Duro Dyne Duroseal, Fosters 32-1, United Duct Sealer (Water Based), and Hardcast 601.
9. Flanged Joint Mastics: One-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
10. Flanged Gasket Tapes: Butyl gasket shall be UL 181 classified. Gasket size shall be minimum 5/8 inch x 3/16 inch and have nominal 100 percent solid content. It shall be non-oxidizing, non-skinning and have a service temperature of –25 to 180 F. Approved Products: Design Polymerics DP 1040, Ductmate 440, and Hardcast 1104.

I. Fire Stopping

1. Fire-Resistant Sealant: Two-part, foamed-in-place, fire-stopping silicone sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.
2. Fire-Resistant Sealant: One-part elastomeric sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.
3. Products: Subject to compliance with requirements, provide one of the following:

   a) "3M Fire Stop Foam"; 3M Corp.
   b) "SPECSEAL Pensil 200 Silicone Foam"; Specify Technology, Inc.
   c) 3M Fire Stop Sealant"; 3M Corp.
   d) "3M Fire Barrier Caulk CP-25"; Electrical Products Div./3M.
   e) "Fyre Putty"; Standard Oil Engineered Materials Co.
   f) “FS-ONE”, Hilti, Inc.

J. Hangers and Supports

1. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
2. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:

    a) Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
    b) Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
    c) Concrete Screw Type Anchors: Complying with ICC-ES AC193.
    d) Masonry Screw Type Anchors: Complying with ICC-ES AC106.
    e) Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.

3. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
4. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.

    a) Hangers Installed In Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.
    b) Straps and Rod Sizes: Conform with SMACNA HVAC Duct Construction Standards, 2005 Edition, for sheet steel width and gauge and steel rod diameters.

5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
6. Trapeze and Riser Supports: Steel shapes conforming to ASTM A 36.

    a) Where galvanized steel ducts are installed, provide hot-dipped-galvanized steel shapes and plates.
    b) For stainless steel ducts, provide stainless steel support materials.
    c) For aluminum ducts, provide aluminum support materials, except where materials are electrolytically separated from ductwork.

7. Wire Rope Hanging Systems:

    a) General: Wire rope hanger system shall have a minimum 5 to 1 safety factor based upon the applied working load being supported.
    b) Source Limitations: Furnish associated fittings, accessories, and hardware produced by a single manufacturer.
    c) Wire Rope: Zinc coated or galvanized steel, with wire thread type as required to support the applied working load being supported.

Provide same size wire for all applications based on worst case loading.

d) Cable Lock: Cast zinc housing with steel spring with wedge grip, selected to meet the vertical load applied to the hanging system and wire thread. Do not exceed the working load limit.

e) Accessories: Hanger attachments and structural attachments shall be compatible with wire rope hanger system and shall be by the same manufacturer as the wire rope hanger system.

f) Manufacturers:

1) ASC Engineered Solutions.
2) Ductmate Industries, Inc; Clutcher Cable Hanging System.
3) Duro Dyne.
4) Gripple.

K. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts. For aluminum and stainless steel ducts provide reinforcing of compatible materials.

L. Tie Rods: Same material as the duct, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 DUCTWORK FABRICATION

A. Fabricate and support duct in accordance with latest edition of SMACNA (DCS).

B. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

1. Fabricate rectangular ductwork of minimum 26 gauge sheet metal.
2. Fabricate ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

C. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

D. Field Painted Ductwork: Provide mill phosphatized finish on exposed surfaces of rectangular ductwork and duct fittings to be field painted.

E. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20 gauge or less, with more than 10 sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 2-9, unless they are lined or are externally insulated.

F. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 2005 Edition, Figures 4-1 through 4-8. Unless otherwise noted on drawings, provide prefabricated 45 degree, high efficiency, rectangular/round branch duct takeoff fittings with manual balancing damper, 3/8 inch square shaft, U-bolt, nylon bushings, locking quadrant, and 2 inch insulation build-out for branch duct connections and take-offs to individual diffusers, registers and grilles. 45 degree, high efficiency, rectangular/round branch duct takeoff fittings shall be Flexmaster STO with model BO3 damper or equal.

G. Provide radius elbows, turns, and offsets with a minimum centerline radius of 1-1/2 times the duct width. Where space does not permit full radius elbows, provide short radius elbows with a minimum of two continuous splitter vanes. Vanes shall be the entire length of the bend. The use of square throat, radius heel elbows is prohibited. Remove and replace all installed elbows of this type with an approved elbow at no additional cost to the owner.

H. Provide mitered elbows where space does not permit radius elbows, where shown on the drawings, or at the option of the contractor with the engineer’s approval. The contractor shall obtain approval to substitute mitered elbows in lieu of radius elbows prior to fitting fabrication. Mitered elbows less than 45 degrees shall not require turning vanes. Mitered elbows 45-degrees and greater shall have single thickness turning vanes of same material and gauge as ductwork, rigidly fastened with guide strips in ductwork. Vanes for mitered elbows shall be provided in all supply and exhaust ductwork and in return and outside air ductwork that has an air velocity exceeding 1000 fpm. Do not install vanes in grease ductwork. Refer to Section “Ductwork Accessories” for turning vane construction and mounting.

I. Provide full radius elbows for ductwork installed in noise critical spaces. Refer to Section “Basic Mechanical Materials and Methods” for noise critical spaces. Where space does not permit the installation of radius elbows, provide mitered elbows with sound attenuating, acoustical turning vanes. Refer to Section “Ductwork Accessories” for acoustical turning vanes.

J. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

K. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

L. Round and Flat Oval Duct Fabrication

1. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct that has a circumference equal to the perimeter of a given sized of flat oval duct. Except where interrupted by fittings, provide round and flat oval ducts in lengths not less than 12 feet.

    a) Fabricate round and flat oval ductwork of minimum 26 gauge sheet metal.

M. Round Ducts: Fabricate round supply ducts using seam types identified in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 3-2, RL-1, RL-4, or RL-5 except where diameters exceed 72 inches. Seam Types RL-2 or RL-3 may be used for ducts smaller than 72 inches in diameter if spot-welded on 1-inch intervals. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams. Comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-5 through 3-13 for galvanized steel gauges. For round duct with static pressure classification of 2 inches water gauge or lower, round supply ducts may be fabricated using snaplock seam types identified in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 3-2, RL-6A, RL-6B, RL-7 or RL-8.

N. Flat Oval Ducts: Fabricate flat oval supply ducts with standard spiral lockseams (without intermediate ribs) or with butt-welded longitudinal seams in gauges listed in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-15.

O. Double-Wall (Insulated) Ducts: Fabricate double-wall insulated ducts with an outer shell, insulation, and an inner liner as specified below. Dimensions indicated on internally insulated ducts are nominal inside dimensions.

1. Outer Shell: Base outer shell gauge on actual outer shell dimensions. Provide outer shell lengths 2 inches longer than inner shell and insulation, and in gauges specified above for single-wall duct.
2. Insulation: Unless otherwise indicated, provide 1-inch-thick. 1.5 pounds per cubic foot density fiber-glass insulation with thermal conductivity performance of 0.27 Btu/sq.ft./°F/inch-thickness at 75°F mean temperature. Provide insulation ends where internally insulated duct connects to single-wall duct or non-insulated components. The insulation end shall terminate the insulation and reduce the outer shell diameter to the nominal single-wall size.
3. Perforated Inner Liner: Construct round and flat oval inner liners with perforated sheet metal of the gauges listed below. Provide 3/32-inch-diameter perforations, with an overall open area of 23 percent. For flat oval ducts, the diameter indicated below is the "basic round diameter."

    a) 3 to 8 inches: 28 gauge with standard spiral construction.
    b) 9 to 42 inches: 28 gauge with single-rib spiral construction.
    c) 44 to 60 inches: 26 gauge with single-rib spiral construction.

d) 62 to 88 inches: 22 gauge with standard spiral construction.

4. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.

P. Round and Flat Oval Fittings Fabrication

1. 90-Degree Tees and Laterals and Conical Tees: Fabricate to conform to SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figures 3-5, 3-6 and 3-7 and with metal thickness specified for longitudinal seam straight duct.
2. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.
3. Elbows: Unless elbow construction type is indicated, provide elbows meeting the following requirements:

a) Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate the bend radius of die-formed, gored, and pleated elbows 1.5 times the elbow diameter.

1) Elbows in Round Duct: Provide full radius elbows.
2) Elbows in Flat Oval Duct: Provide full radius elbows. Where space limits the installation of full radius elbows, short radius elbows with a minimum of two continuous splitter vanes shall be installed. Vane length shall be the entire length of the bend or 36 inches whichever is greater.
3) The use of square throat, radius heel elbows is prohibited. Remove and replace all installed elbows of this type with an approved elbow at no additional cost to the owner.
4) Provide full radius elbows for ductwork installed in noise critical spaces or where shown on the drawings. Refer to Section “Basic Mechanical Materials and Methods” for noise critical spaces.

b) Mitered Elbows: Fabricate mitered elbows with welded construction in gauges specified below.

1) Mitered Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-1.
2) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from minus 2 inches to plus 2 inches:

a) 3 to 26 inches: 24 gauge.
b) 27 to 36 inches: 22 gauge.

c) 37 to 50 inches: 20 gauge.
d) 52 to 60 inches: 18 gauge.
e) 62 to 84 inches: 16 gauge.

3) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from 2 inches to 10 inches:

a) 3 to 14 inches: 24 gauge.
b) 15 to 26 inches: 22 gauge.
c) 27 to 50 inches: 20 gauge.
d) 52 to 60 inches: 18 gauge.
e) 62 to 84 inches: 16 gauge.

4) Flat Oval Mitered Elbows: Solid welded and with the same metal thickness as longitudinal seam flat oval duct.
5) 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material handling classes A and B; and only where space restrictions do not permit the use of 1.5 bend radius elbows. Fabricate with a single-thickness turning vane.

c) Round Elbows - 8 Inches and Smaller: Die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 3-1/2- and 4-1/2-inch) elbows with gored construction.
d) Round Elbows - 9 Through 14 Inches: Gored or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a mitered elbow. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 9-1/2- and 10-1/2-inch) elbows with gored construction.
e) Round Elbows - Larger Than 14 Inches and All Flat Oval Elbows: Gored elbows, except where space restrictions require a mitered elbow.
f) Die-Formed Elbows for Sizes Through 8 Inches and All Pressures: 20 gauge with 2-piece welded construction.
g) Round Gored Elbows Gauges: Same as for non-elbow fittings specified above.
h) Flat Oval Elbows Gauges: Same as longitudinal seam flat oval duct.
i) Pleated Elbows Sizes Through 14 Inches and Pressures Through 10 Inches: 26 gauge.

4. Double-Wall (Insulated) Fittings: Fabricate double-wall insulated fittings with an outer shell, insulation, and an inner liner as specified below. Dimensions indicated on internally insulated ducts are nominal inside dimensions.

a) Outer Shell: Base outer shell gauge on actual outer shell dimensions. Provide outer shell lengths 2 inches longer than inner shell and insulation. Gauges for outer shell shall be same as for uninsulated fittings specified above.
b) Insulation: Unless otherwise indicated, provide 1-inch-thick. 1.5 pounds per cubic foot density fiber-glass insulation with thermal conductivity performance of 0.27 Btu/sq.ft./°F/inch-thickness at 75°F mean temperature. Provide insulation ends where internally insulated duct connects to single-wall duct or non-insulated components. The insulation end shall terminate the insulation and reduce the outer shell diameter to the nominal single-wall size.
c) Perforated Inner Liner: Construct round and flat oval inner liners with perforated sheet metal of the gauges listed below. Provide 3/32-inch-diameter perforations, with an overall open area of 23 percent. For flat oval ducts, the diameter indicated in the table below is the "basic round diameter."

1) 3 to 34 inches: 24 gauge.
2) 35 to 58 inches: 22 gauge.
3) 60 to 88 inches: 20 gauge.

d) Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.

5. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:

a) Round Elbows 4 to 8 Inches: 2-piece, die stamped, with longitudinal seams spot welded, bonded, and painted with a PVC aerosol spray.
b) Round Elbows 9 to 26 Inches: Standing seam construction.
c) Round Elbows 28 to 60 Inches: Standard gore construction, riveted and bonded.
d) Other Fittings: Riveted and bonded joints.
e) Couplings: Slip-joint construction with a minimum of a 2-inch insertion length.

Q. Shop Application of Liner in Rectangular Ducts

1. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
2. Apply a coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
3. Butt transverse joints without gaps and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.

5. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

   a) Apply an adhesive coating on longitudinal seams in ducts exceeding 2,500 FPM air velocity.

6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:

   a) Fan discharge.
   b) Intervals of lined duct preceding unlined duct.
   c) Upstream edges of transverse joints in ducts where duct velocity is greater than 2,500 FPM.

8. Secure insulation liner with perforated sheet metal liner of the same gauge specified for the duct, secured to ducts with mechanical fasteners that maintain metal liner distance from duct without compressing insulation. Provide 3/32-inch-diameter perforations, with an overall open area of 23 percent.
9. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to the duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire damper sleeve through fire separation.

2.04 MANUFACTURED DUCTWORK AND FITTINGS

A. General: At the Contractor’s option, factory-manufactured ductwork can be provided instead of fabricated ductwork for round and oval ductwork. The round duct system shall consist of fittings that are factory fitted with a sealing gasket and spiral duct which, when installed according to the manufacturer's instructions, will seal the duct joints without the use of duct sealer. The oval duct system shall be sealed with duct sealer as specified.

   1. Ducts shall be calibrated to manufacturer's published dimensional tolerance standard.
   2. All duct 14" diameter and larger shall be corrugated for added strength and rigidity.
   3. Spiral seam slippage shall be prevented by means of a flat seam and a mechanically formed indentation evenly spaced along the spiral seam.

4. Ducts shall be constructed using spiral lock seam sheet metal construction.
5. Ductwork to be installed in exposed locations shall have the surface prepared in the factory for field painting.

B. Duct Construction

1. Unless otherwise noted, all duct and fittings shall be constructed from galvanized steel in accordance with SMACNA's Duct Construction Standards for +10” water gauge pressure with minimum wall thickness as shown in the following tables:

Single Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct (ga)	Galvanized Fittings (ga)
3-14	28	24
15-24	26	24
26-42	24	22
42-60	22	20

Double Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct (ga)		Galvanized Fittings (ga)	
	Inner	Outer	Inner	Outer
3-14	28	28	24	24
16-24	26	26	24	24
26-42	24	24	22	22
44-60	22	22	20	20

Oval Duct:

Major Axis (Inches)	Galvanized Spiral Duct (ga)	Galvanized Fittings (ga)
3-24	24	20
25-38	22	20
37-48	22	18
49-60	20	18
61-70	20	16
71 and large	18	16

2. Duct shall be calibrated to manufacturer's published dimensional tolerance standard.
3. Ducts shall be constructed using spiral lock seam sheet metal construction.
4. Ductwork to be installed in exposed locations shall be factory-prepared for field painting, i.e. mill-phosphatized..

C. Fittings:

1. All fitting ends for round duct and transitions and divided flow fittings smaller than 24” diameter that convert oval duct to round duct shall come factory equipped with a double lipped, U-profile, EPDM rubber gasket. Gasket shall be manufactured to gauge and flexibility so as to ensure that system will meet all of the performance criteria set forth in the manufacturer's literature. Gasket shall be classified by Underwriter's Laboratories to conform to ASTM E84-91a and NFPA 90A flame spread and smoke developed ratings of 25/50.
2. All fittings shall be calibrated to manufacturer's published dimensional tolerance standard and associated spiral duct.
3. All fitting ends from 5" to 60" diameter shall have rolled over edges for added strength and rigidity.
4. All elbows from 5" to 12" diameter shall be 2 piece die stamped and continuously stitch welded. All elbows 14" diameter and larger shall be standing seam gorelock construction and internally sealed.
5. The radius of all 90° and 45° elbows shall be 1.5 times the elbow diameter, unless otherwise noted on the contract documents to be 1.0. The radius of all 15°, 30° and 60° elbows shall be minimum 1.0 times the elbow diameter.
6. All fittings that are of either spot welded or button punched construction shall be internally sealed. When contract documents require divided flow fittings, only full body fittings will be accepted. The use of duct taps is unacceptable except for retrofit installations.
7. Double wall duct and fittings shall consist of a perforated or solid inner liner, a 1 inch, 1.50 pounds per cubic foot (unless otherwise specified) layer of fiberglass insulation and a solid outer pressure shell. Perforated inner liner shall have a retaining fabric wrapped between the perforated inner and the fiberglass insulation. This fabric shall provide fiberglass tear retention while maintaining the desired acoustical properties. For 1 inch thick insulation, the outer pressure shell diameter shall be 2 inches larger than the inner liner.
8. All double wall fittings for round duct shall be furnished with the manufacturer’s standard gasket on the outer shell. The inner shell on all double wall fittings shall extend a minimum of 1 inch past the outer shell.
9. Double wall to single wall transitions shall be provided where insulated duct connects to non-insulated, single wall duct. Transitions shall also act as insulation ends reducing the double wall outer shell diameter to the inner shell diameter.
10. All double wall duct and fittings shall be furnished with both an inner liner and an outer pressure shell coupling. The inner liners shall not be fastened tighter to allow for expansion and contraction.
11. All volume dampers shall be Lindab Safe type DRU, DSU or DTU or equal by an acceptable manufacturer. Damper shall be fitting sized to slip into spiral duct. Damper shall have the following features:

    a) Locking quadrant with blade position indicator.
    b) 2" sheet metal insulation stand-off.

c) Integral shaft/blade assembly.
d) Shaft mounted, load bearing bushings.
e) Gasketed shaft penetrations to minimize leakage.

D. Manufacturers:

1. Hercules Industries.
2. Lewis & Lambert.
3. Lindab Safe.
4. Linx Industries, Inc.
5. Semco.

2.05 SNAP-LOCK DUCT SYSTEM

A. General: At Contractor's option, snap-lock round ductwork can be provided instead of fabricated ductwork for round ductwork up to 14" in diameter in air systems with pressures between negative 1" and positive 2" w.c..

B. Duct Construction:

1. Material:

a) Galvanized steel conforming to ASTM A653 and A924 with G-60 galvanized coating conforming to ASTM A653 and ASTM A90.

2. Duct shall be minimum 26 gauge. Duct shall be self-locking and incorporate a factory applied gasket in the longitudinal seam and the female end of the traverse joint to provide a system that meets SMACNA Seal Class A.
3. Fittings: Minimum 26 gauge. All high-efficiency take-offs, conicals, and collars shall have a factory applied gasket along all rivets, co-latches, and flanges. Dampered fittings shall have low leakage hardware with closed-end bearings.

C. Gaskets: Gaskets shall be made of butyl and EPDM rubber that meets flame spread index of 25 and smoke spread index of 50 according to ASTM E84.

D. Manufacturers:

1. Ductmate GreenSeam.
2. Approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).

B. Install products in accordance with manufacturer's instructions.

C. Install ducts with the fewest possible joints.

D. Seal duct joints with the appropriate sealing material.

E. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

F. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

G. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Provide clearance of 1 inch where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.

J. Install insulated ducts with 1-inch clearance outside of insulation.

K. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.

L. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

M. Exposed Ductwork: Exposed ductwork shall be free of defects, dents or blemished surfaces to provide a smooth, finished appearance. Any damaged material shall be replaced with new material. Ductwork that is to be field painted shall have surfaces wiped clean of lubricant, dirt, or fil prior to priming and painting. Apply primer and paint of type as recommended by paint manufacturer for duct material and finish.

N. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

O. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2 inches.

P. Acoustical Barrier Penetrations: Where a duct passes through a wall, ceiling or floor slab of a noise critical space, provide a clear annular space of 1-inch between the duct and the structure. Refer to Section “Common Work Results for HVAC” for noise critical spaces. The Contractor shall check the clearance and, if clearance is acceptable, shall install the duct and pack the voids full depth with mineral fiber batt insulation. Contractor shall caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material. Where there is insufficient clearance space, Contractor shall place a short stub duct in the wall, pack and caulk around it and then attach the inlet and outlet ducts to each end.

Q. Cover ducts openings during construction with duct caps or three-mil plastic to protect inside of (installed and delivered) ductwork from exposure to dust, dirt, paint and moisture. Do not use duct tape on ducts that will be exposed or painted.

R. Duct Liner Installation

1. Fiberglass Duct Liner:

a) Attach fiberglass duct liner using fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50-pound tensile dead load test perpendicular to the duct wall.

2. Flexible Elastomeric Duct Liner:

a) Install liner in accordance with the manufacturer’s installation instructions or ASTM C 1710.
b) Attach flexible elastomeric duct liner to clean, oil-free sheet metal surfaces with adhesive as recommended by the liner manufacturer.
c) Seal all longitudinal seams and end joints with manufacturer’s recommended adhesive and install compression joints in accordance

with manufacturer's instructions to eliminate any openings in insulation that would allow passage of air to duct surface being insulated.

3. Polyester Duct Liner:

a) Install polyester duct liner per SMACNA Manual, "HVAC Duct Construction Standards, Metal and Flexible," unless otherwise specified.
b) Attach polyester duct liner using a nonflammable, low VOC water based adhesive.
c) Apply a nonflammable, low VOC water based lagging adhesive to the exposed leading edge of the insulation.
d) Install fasteners per SMACNA HVAC Duct Liner installation instructions.

S. Kitchen Hood Exhaust

1. Provide for thermal expansion of ductwork through 2,000°F temperature range.
2. Install without dips or traps that may collect residues, except where traps have continuous or automatic residue removal.
3. Horizontal Ducts:

a) Provide at least one opening that is minimum size of 20 inches by 20 inches for personnel entry. Where an opening of this size is not possible, provide access openings at each change in direction and at 12-foot intervals. Locate openings on sides of duct 1-1/2 inches minimum from bottom, and fit with grease-tight covers of same material as duct. Support systems for ducts 24 inch and larger in any dimension shall be designed for the weight of the duct plus 800 pounds at any point in the duct system.
b) Slope horizontal ductwork serving a Type I hood back toward the hood or local grease reservoir a minimum of 1/4 inch per foot. Horizontal ducts that exceed 75 feet in length shall be sloped not less than 1 inch per foot.

4. Vertical Ducts:

a) For ducts larger than 24 inches by 24 inches, provide a 20 inch by 20 inch access opening for personnel entry at the top of the vertical riser.
b) For ducts smaller than 24 inches by 24 inches, provide an access opening at each floor level in a location that is accessible and not higher than 12 feet above finished floor.

c) Supports for ducts large enough for personnel entry shall be designed for the weight of the duct plus 800 lbs at any point in the duct system.

5. Provide transition at connection to fan with opening size equal to or greater than the venturi opening of the fan inlet. Provide gasket at flanged connection to fan rated for 1500 F and grease applications.
6. Do not penetrate fire-rated assemblies without providing shaft, field-applied or factory-built enclosure.

T. Dishwasher Exhaust Duct Installations

1. Install dishwasher exhaust duct systems in accordance with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 10-2.
2. Slope horizontal ductwork back towards dishwasher hood a minimum of 1/4" per foot. Where distance does not allow continuous slope in ductwork, provide low point drains with the following:

a) Drip leg with 3/4 inch plenum rated drain tubing routed to discharge at code approved location.
b) Pigtail trap or U-trap sized for system pressure.

U. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

V. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

W. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.

X. Seam and Joint Sealing

1. General: Seal duct seams and joints as follows:

a) All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed to meet SMACNA Seal Class A.
b) Seal class shall apply to all supply, return, outdoor air, and exhaust ductwork, regardless if the duct is positively or negatively pressurized. Transfer air ducts and sound boots do not need to be sealed.

2. Seal externally insulated ducts prior to insulation installation.

3. Ductwork installed exterior to the building shall have longitudinal and transverse joints welded or sealed airtight with weatherproof heavy liquid sealant applied according to manufacturer's instructions.

Y. HANGING AND SUPPORTING

1. Install rigid round, rectangular, and flat oval metal duct with support systems per SMACNA standards.
2. The use of wire rope hanging systems is an acceptable alternate hanging method when installed in strict accordance with manufacturer’s instructions. Wire rope hanger spacing shall not exceed 8 feet. Supported load shall not exceed manufacturer’s recommended load rating.

   a) Where approved by local code authority, the loop system may be swaged directly on to a seismic approved bracket or appropriate end fixing.

3. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.
4. Support vertical ducts at a maximum interval of 16 feet and at each floor.
5. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated. Hangers and supports shall be fastened to building joists or beams. Do not attach hangers and supports to the above floor slab or roof with sheet metal screws.
6. Install concrete insert prior to placing concrete.
7. Install powder actuated concrete fasteners after concrete is placed and completely cured.
8. Provide double nuts and lock washers on threaded rod supports.
9. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

Z. Penetrations

1. Fire Barrier Penetrations: Where ducts pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity.
2. Underground Exterior Wall Penetrations: Seal duct penetrations through underground exterior walls with sleeves, packing, and sealant. Refer to Division 23 Section “Basic Piping Materials and Methods” for additional information.
3. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of No-Fire Rated Walls and Concrete Slab on Grade Penetrations: Seal ducts that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 23 Section "Basic Piping Materials and Methods” for special sealers and materials.

AA. CONNECTIONS

1. Equipment Connections: Connect equipment with flexible connectors in accordance with Division 23 Section "Air Duct Accessories."
2. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards”.
3. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards". Where a 90-degree elbow is required at the connection to air devices, provide a rigid duct elbow or, at Contractor’s option, a flexible elbow assembly as specified in Division 23 Section "Air Duct Accessories."
4. Fan Connections: Comply with SMACNA "HVAC Duct Construction Standards”.

3.02 FIELD QUALITY CONTROL

A. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

B. General Duct Systems: Perform leakage tests in accordance with ASHRAE and SMACNA standards.

1. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing, and as required for compliance with test requirements.
2. Conduct tests, in the presence of the Architect, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give 7 days' advanced notice for testing. Submit a letter report to the Owner and Engineer summarizing the test procedures followed, systems tested and the results of the leakage tests.
3. Determine leakage from entire system or section of the system by relating leakage to the surface area of the test section.
4. Maximum Allowable Leakage: As described in ASHRAE 2005 Handbook, "Fundamentals" Volume, Chapter 35, Table 9 and Figure 13. Comply with requirements for leakage classification 3 for round and flat oval ducts, leakage classification 12 for rectangular ducts in pressure classifications less than and equal to 2 inches water gauge (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 2 inches water gauge and less than and equal to 10 inches water gauge.
5. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.
6. Leakage Test: Perform volumetric measurements and adjust air systems as described in ASHRAE 2003 "HVAC Applications" Volume, Chapter 37

and ASHRAE 2005 "Fundamentals" Volume, Chapter 14, and Division 23 Section "TESTING, ADJUSTING, AND BALANCING FOR HVAC."

C. Ductwork with Pressure Rating > 3" W.C.: Ducts and plenums shall be leak tested in accordance with SMACNA HVAC Air Duct Leakage Test Manual to prove they meet leakage classification less than or equal to 6. Submit test reports to the Engineer of Record demonstrating that at least 25 percent of the installed duct area has been tested and pass this test.

D. Grease Duct Leakage Test: All portions of grease duct systems shall be tested for leakage in accordance with Chapter 5, Section 506 of the locally adopted IMC. Leakage tests shall be by light or other equivalent test methods as approved by the local code official to verify that all joints are liquid tight. Tests shall be performed in the presence of the local code official. Any joints found defective shall be repaired and retested until satisfactory results are obtained. The contractor shall submit a copy of the grease duct leakage test report to the Architect and Engineer complete with the approval signature of the local code official.

3.03 ADJUSTING, STARTUP AND CLEANING

A. Adjust volume control devices as required by the testing and balancing procedures to achieve required air flow. Refer to Division 23 Section "TESTING, ADJUSTING, AND BALANCING FOR HVAC" for requirements and procedures for adjusting and balancing air systems.

B. Vacuum duct systems prior to final acceptance to remove dust and debris.

C. Remove temporary protection devices over ductwork prior to starting equipment and turning the system over to the owner.

D. If permanent HVAC equipment is used during the construction period, provide temporary filters at all openings in the ductwork and at inside equipment to protect the system from dust, dirt, paint, and moisture. Replace and maintain filters when needed, but not less than every month. On the day of substantial completion, clean the duct system and provide a new set of filters in the HVAC unit.

1. Refer to Division 23 Section 234100 Particulate Air Filtration for filter requirements.

3.04 CLEANING NEW SYSTEMS

A. Contractor shall clean the HVAC systems in accordance with NADCA.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

C. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.

a) Do not degrade structural, thermal or functional system integrity of the duct.
b) Provide access doors complying with UL 181 to cover new openings. Refer to Division 23 Section “Air Duct Accessories”.
c) Seal openings with tape and sealant complying with UL 181A.

2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

D. Vent vacuuming system to the outside. Provide filtration and/or containment systems to keep debris removed from HVAC systems from contaminating other spaces. Locate exhaust down wind and away from air intakes and other points of entry into building.

E. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply and outdoor air ducts, dampers, actuators, and turning vanes.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment while the system is under negative pressure; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to ACR 2002. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

G. Disposal: Debris collected from the HVAC system shall be disposed of in accordance with applicable federal, state and local requirements.

H. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and re-inspect ducts.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Turning vanes.

B. Backdraft dampers.

C. Combination fire and smoke dampers.

D. Duct access doors.

E. Duct hardware.

F. Fire dampers.

G. Flexible duct connectors.

H. Volume control dampers.

I. Duct opening closure film.

J. Cable operated damper systems.

K. Fire rated duct wrap.

L. Flexible ductwork.

M. Flexible elbow assembly.

1.02 REFERENCE STANDARDS

A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.

B. ASTM A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. ASTM E477 - Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

E. ASTM E814 - Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops.

F. ASTM E 2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

G. ISO 6944 - Fire Containment — Elements of Building Construction.

H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

I. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

J. NFPA 92 - Standard for Smoke Control Systems.

K. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

L. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

M. UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.

N. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

O. UL 181 - Factory-Made Air Ducts and Connections.

P. UL 263 - Standard for Fire Tests of Building Construction and Materials; Current Edition, Including All Revisions.

Q. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.

R. UL 555C - Standard for Safety Ceiling Dampers.

S. UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

T. UL 1479 - Fire Tests of Through-Penetration Firestops.

U. UL 1978 - Grease Ducts; Current Edition, Including All Revisions.

V. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; Current Edition, Including All Revision

1.03 SUBMITTALS

A. Product Data: Provide for each type of ductwork accessory the following:

1. Electrical characteristics.
2. Connection requirements.

3. Dimensions.
4. Capacities
5. Materials of construction.

B. Shop Drawings: Indicate for shop fabricated assemblies the following:

1. Interfacing requirements with ductwork.
2. Method of fastening or support.
3. Methods of assembly of components.

C. Performance Data: Submit performance data for duct silencers including insertion loss performance in octave bands from 63 Hz to 8,000 Hz and pressure drop at specified airflow.

D. Project Record Drawings: Record actual locations of access doors and test holes.

E. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. SMACNA Compliance: Comply with applicable portions of SMACNA (DCS).

C. UL Compliance:

1. Fire Dampers: Construct, test, and label fire dampers in accordance with current edition of UL Standard 555.
2. Smoke Dampers: Construct, test, and label smoke dampers in accordance with current edition of UL Standard 555S.
3. Flexible Ductwork: Construct flexible ductwork in compliance with UL Standard 181.
4. Duct Tape: Label in accordance with UL Standard 181B and marked 181B-FX.
5. Duct Clamps: Label in accordance with UL Standard 181B and marked 181B-C.
6. Fire Rated Duct Wrap: Meet the fire protection requirements defined by UL Standard 1479.
7. Grease Exhaust Duct Wrap: Meet the fire protection requirements defined by UL Standard 1479.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated

E. NFPA Compliance:

1. Comply with applicable provisions of NFPA 90A and NFPA 90Bpertaining to installation of ductwork accessories.
2. Comply with NFPA 96 for fire-rated grease exhaust ducts.

F. ASTM Compliance: Products shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 “Surface Burning Characteristics” (NFPA 255) method.

1. Grease exhaust duct wrap shall be tested for performance in accordance with ASTM E 2336 “Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems” and ASTM E814 “Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops”.
2. Fire rated duct wrap shall be tested in accordance with ASTM E814 “Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops”.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork accessories during shipping and storage from dirt, debris and moisture damage.

B. Protect dampers from damage to operating linkages and blades.

1.06 SPARE PARTS

A. Extra Fusible Links: One link for every 10 installed of each type, size and temperature range. Obtain receipt.

PART 2 - PRODUCTS

2.01 TURNING VANES

A. Manufacturer:

1. Aero Dyne Co.
2. Anemostat Products Div.; Dynamics Corp. of America.
3. Ductmate Industries.
4. Duro Dyne Corp.
5. Elgen Manufacturing Co., Inc.
6. Hart & Cooley Mfg. Co.
7. Register & Grille Mfg. Co., Inc
8. Sheet Metal Connectors, Inc.

B. Manufactured Turning Vanes: Provide turning vanes and runners fabricated from galvanized sheet metal, lock-forming quality, ASTM A 653, minimum Coating Designation G 60, of the same gauge thickness or greater as the ductwork in which they are installed.

1. Vanes shall be rigidly fastened with guide strips to minimize noise and vibration.
2. Vanes in ductwork over 30" deep shall be installed in multiple sections with vanes not over 30" long and shall be rigidly fastened.
3. Turning vanes shall be constructed per SMACNA Duct Construction Standards Metal and Flexible – 2005 Edition, Figure 4-3 and set into side strips suitable for mounting in ductwork.

C. Acoustical Turning Vanes: Provide acoustical turning vanes constructed of airfoil shaped aluminum extrusion with perforated faces and fiberglass fill in systems serving noise critical spaces. Refer to Section "Common Work Results for HVAC" for noise critical spaces.

2.02 BACKDRAFT DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Arrow United Industries.
3. Cesco
4. Greenheck
5. Louvers & Dampers, Inc.
6. Nailor Industries, Inc.
7. Pottorff
8. Ruskin Mfg. Co.
9. TAMCO
10. Vent Products

B. Backdraft Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to open at indicated static pressure. Provide adjustment device to permit setting for varying differential static pressure

1. Construct frames of minimum16 gauge galvanized steel or 10 gauge aluminum.
2. Construct blades of minimum 16 gauge aluminum.
3. Provide minimum 1/2" diameter, corrosion-resistant bearings and 1/2" diameter, galvanized or stainless steel axles.
4. Mechanically lock blade edge seals into blade edge. Provide neoprene seals for round dampers and silicone or vinyl seals for rectangular dampers.

2.03 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Cesco Products.
3. Greenheck
4. Louvers & Dampers, Inc.
5. Nailor Industries, Inc.

6. Pottorff
7. Prefco Products, Inc.
8. Ruskin Mfg. Co.

B. General: Provide combination fire and smoke dampers at locations indicated on the drawings. Damper ratings shall be as required to maintain the fire and/or smoke ratings noted on the architectural drawings. Provide duct access door for inspection and service to each fire and smoke damper and fusible link as required. Provide sleeves of length as required to meet the installed location. Damper assemblies shall be provided as a single unit from the manufacturer.

C. Fabricate dampers in accordance with NFPA 90A, UL555 (current edition) classified fire damper of rating required for location installed, UL555S (current edition) classified smoke damper for leakage class II and rated for dual directional airflow.

D. Fire/smoke dampers shall be rated for closure in ducts up to minimum velocity of 2,000 fpm and static pressure of 4” w.g.

E. Multiple Blade Dampers:

1. Frame: Minimum 16-ga galvanized steel. Construct casings of 16 gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings.
2. Blades: Minimum 22 gauge thickness with airfoil or longitudinal grooved shape for airflow velocities up to 2,000 fpm and airfoil shape for airflow velocities greater than 2,000 fpm.
3. Bearings: Self-lubricating, turning in extruded hole in the frame.
4. Linkage: Plated steel axles, linkage concealed in frame, 1/2” actuator shaft.
5. Seals: Flexible, stainless steel jamb seals, silicone rubber blade seals with galvanized steel mechanical locked in to the blade edge and stainless steel spring loaded leakage seals in sides of casing. Provide stainless steel spring loaded leakage seals in sides of casing, and the following additional features:

    a) Open-closed indication switch.

F. Operators:

1. UL listed and labeled.
2. Spring return open/fail closed operation.
3. Two-position or modulating as required for the installation.
4. Electric type suitable for 120 Volts, single phase, 60 Hz.
5. Factory installed on dampers.
6. All operators shall open in between 7 and 15 seconds and close in between 7 and 15 seconds after alarm or smoke detection has occurred.
7. Rated for a minimum of 20,000 cycles of operation.
8. Provide automatic reset of damper upon cessation of detector (test or actual smoke detection), and normalization of duct air temperature.

G. Electro Thermal Link: Provide resettable temperature device rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated.

H. Smoke Activation:

1. Provide terminal block for connection to the building fire alarm system.

I. Accessories:

a) Open-closed indication switch.

2.04 DUCT ACCESS DOORS

A. Manufacturers:

1. Air Balance Inc.
2. Ductmate Industries.
3. Duro Dyne Corp.
4. Greenheck.
5. Register & Grille Mfg. Co., Inc.
6. Ruskin Mfg. Co.
7. Ventifabrics, Inc.
8. Vent Products.
9. Zurn Industries, Inc.; Air Systems Div.

B. Provide, where indicated on the drawings or where specified in Part 3 of this section, duct access doors of size allowable by duct dimensions with, unless otherwise noted on the drawings, minimum size of 10” by 10” and maximum size of 24” by 24”. Fabricate in accordance with SMACNA (DCS) and as indicated. Label access doors for fire and smoke dampers as specified in Part 3.

C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. Construct of same or greater gauge as ductwork served. For insulated ductwork. install minimum 1 inch thick insulation with sheet metal cover. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct.

1. 12 inches square or less: Provide one size hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors. Provide removable section of duct where duct size is too small for a 10” by 10” access door.
2. Larger than 12 inches square: Provide two hinges and two handle-type latches.

2.05 DUCT HARDWARE

A. Manufacturers:

1. Ductmate Industries.
2. Elgen Manufacturing Co., Inc.

3. Ventfabrics, Inc.
4. Young Regulator Co.

B. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated.

1. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
2. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

C. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.06 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Cesco Products.
3. Greenheck
4. Louvers & Dampers, Inc.
5. Nailor Industries, Inc.
6. Pottorff
7. Prefco Products, Inc.
8. Ruskin Mfg. Co.

B. General: Provide fire dampers at locations indicated on the drawings. Damper ratings shall be as required to maintain the fire ratings noted on the architectural drawings. Provide duct access door for inspection and service to each fire damper and fusible link as required. Provide sleeves of length as required to meet the installed location.

C. Fabricate in accordance with NFPA 90A and UL 555 and as indicated.

D. Fire dampers shall be dynamic-rated for closure under pressure.

E. Provide positive lock in closed position.

F. Ceiling Radiation Dampers

1. General: Conform to UL 555C or tested in accordance with UL 263.
2. Casing: Galvanized steel frame in gauges as required to maintain applicable UL classification.
3. Damper Blades: Galvanized steel with UL classified thermal insulation as required to meet UL criteria and fire and smoke ratings noted on the architectural drawings.
4. Fusible link: Integral to device, rated at 165 degrees F.

5. Accessories: Provide as required for the installation:

a) Volume Controller: Manually adjustable volume controller integral to the assembly used to regulate airflow through the damper for testing and balancing.

b) Boot Fitting: Factory provided elbow, end or straight type. Include field provided collar, flanged recess, or ceramic thermal blanket.

c) Box Fitting: Factory provided 26 gauge with field provided collar, flanged recess, or ceramic thermal blanket.

G. Horizontal Dampers: Minimum 22 gauge galvanized steel frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket. Construct casings of 20 gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings.

H. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream. Construct frames of 20-gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings.

I. Multiple Blade Dampers: Minimum 16 gauge, galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock. Construct frames of 20-gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings

J. Fusible links: UL 33 rated at 160 to 165 degrees F unless otherwise indicated.

K. Accessories:.

2.07 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:

1. Carlisle HVAC Products.
2. Ductmate Industries.
3. Duro Dyne Corp.
4. Elgen Manufacturing Co., Inc.
5. Ventfabrics, Inc.

B. Fabricate in accordance with SMACNA (DCS) and as indicated. Flexible connectors shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

C. Flexible Duct Connections: Fabric crimped into metal edging strip. Provide metal compatible with connected ducts. Factory fabricated. Flame-retardant or noncombustible fabrics compliant with NFPA 701.

1. Indoor Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric compliant with NFPA 90A.

    a) Minimum Weight: 26 oz./sq. yd.
    b) Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
    c) Service Temperature: Minus 40 to plus 200 deg F.

2. Metal: Factory fabricated with a fabric strip minimum 3-1/2 inches wide attached to two strips of minimum 24 gauge galvanized sheet steel or 0.032-inch- thick aluminum.

D. Maximum Installed Length: 14 inch.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

2.08 VOLUME CONTROL DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Arrow United Industries
3. Cesco
4. Greenheck
5. Louvers & Dampers, Inc.
6. Nailor Industries, Inc.
7. Pottorff
8. Rossi Air Flow
9. Ruskin Mfg. Co.
10. TAMCO
11. Vent Products

B. Fabricate dampers in accordance with SMACNA (DCS) and as indicated. Construct using galvanized steel for standard air systems, aluminum for wet or natatorium environments and stainless steel for corrosive environments.

C. Single Blade Dampers:

1. Fabricate for duct sizes up to 12 x 36 inch.
2. Blade: 20 gauge, 0.04 inch, minimum.

D. Multi-Blade Damper: Fabricate of parallel or opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

1. Blade: 18 gauge, 0.0478 inch, minimum.

E. Bearings: Corrosion resistant, molded synthetic.

F. Axles: Positively lock into the damper blade.

G. Blade Seals: Where used for shutoff duty, provide Neoprene seals for round dampers and silicone for rectangular dampers.

H. Quadrants:.

1. Provide locking, indicating quadrant regulators.
2. On insulated ducts, provide extended shafts and mount regulator on standoff bracket, base or adapter.
3. Where rod lengths exceed 48 inches, provide regulator at both ends.

2.09 DUCT OPENING CLOSURE FILM

A. Mold-resistant, self-adhesive film to keep debris out of ducts during construction.

B. Thickness: 2 mils.

C. High tack water-based adhesive.

D. UV stable.

E. Elongation Before Break: 325 percent, minimum.

2.010 CABLE OPERATED DAMPER SYSTEMS

A. Manufacturer:

1. DuroDyne, DuroZone.
2. Metropolitan Air Technology, Inc. (Reference model number for round damper is RT-250 and for rectangular damper is RT-200).
3. Young Regulator Co. (Reference model number is 270).

B. General: Where access to dampers through a hard ceiling is required, provide a concealed, remote cable-operated, butterfly-type volume damper assembly with external worm gear operator.

C. Damper assembly shall include duct casing with rolled bead stiffeners, reinforced blade, self-lubricating bearing, and remote operator mounting plate.

D. Adjustable through the diffuser frame with standard 1/4 inch nut-driver or flat screwdriver.

E. Cable assembly shall attach to damper as a single piece with no linkage adjustment required.

F. Positive, direct, two-way damper control with no sleeves, springs or screw adjustments to come loose after installation.

G. Cable length as required to span the distance from the damper to the remote operator location.

H. Where approved by Architect, a ceiling cup with cover plate can be used for access to cable operator.

2.011 FIRE RATED DUCT WRAP

A. Manufacturers:

1. 3M.
2. Pyroscat
3. Thermal Ceramics
4. Unifrax Corporation

B. Grease Exhaust Ducts:

1. Reference manufacturer and model number is Unifrax FyreWrap Elite 1.5.
2. Minimum two-hour rated duct wrap insulation for Type I hood grease exhaust duct applications.
3. Two layers of 1-1/2 inch thick.
4. Density: Minimum 6 lb. per cubic foot.
5. Zero clearance to combustibles.
6. Flexible wrap enclosure rated for minimum 2000 F.
7. Material: Non-mineral wool, passive, low biopersistant fiber totally encapsulated with aluminum foil reinforced with scrim. UL Listed in accordance with ASTM E2336.
8. Attachments:

   a) Ducts smaller than 24” by 24” in size, provide stainless steel bands at insulation seams and on maximum 12 inch centers to hold the outer layer of the blanket enclosure in place.
   b) Ducts larger than 24” by 24” in size, provide pins to hold the outer layer in place.

9. Insulation shall be tested for intended use in accordance with all applicable codes and shall be approved by the local code official.
10. Provide factory-built access doors by same manufacturer as fabricated for use specifically with the insulation system.

C. General for HVAC Ducts:

1. Reference Manufacturer and Model Number is Unifrax FyreWrap Elite 1.5.
2. Provide duct wrap insulation for HVAC ducts required to be in rated enclosure construction where dampers are restricted.
3. One, two or three hour-rating as required for the installation.
4. 1-1/2 inch thick wrap.
5. Density: Minimum 6 lb. per cubic foot.
6. Zero clearance to combustibles.
7. Flexible wrap enclosure rated for minimum 2000 F.
8. Applied in one or more layers to achieve the hourly rating requirement.
9. Material: Non-mineral wool, passive, low biopersistant fiber totally encapsulated on all sides with aluminum foil reinforced with scrim. UL

Listed in accordance with ISO 6944 and UL 1479, and as acceptable to the Authority Having Jurisdiction.

D. Access Doors:

1. Manufacturer and/or model number:

   a) Ductmate Ultimate.
   b) FlameGard.
   c) Thermal Ceramics FastDoor XL.
   d) Equivalent.

2. Duct access door to be tested and listed in accordance with UL1978.
3. Gaskets: Liquid tight and minimum 1500F rated.
4. Duct access to be provided with 2-hour and zero clearance insulation cover tested and UL Listed per ASTM E2336 by same manufacturer and as fabricated for use specifically with the insulation system.

2.012 FLEXIBLE DUCTWORK

A. Manufacturers:

1. ATCO Rubber Products.
2. Flexmaster.
3. JPL (J.P. Lamborn Co)
4. Thermaflex.

B. Construction: Provide flexible ductwork conforming to UL 181-Class I, NFPA 90A and NFPA 90B and as follows. Duct types of manufacturers are indicated for reference in regard to required quality of construction and materials.

C. Insulated Flexible Ductwork: Provide duct fabric of ply-vinyl film, polyethylene film or multiple layers of aluminum laminate supported by helically wound spring steel wire. Wrap fabric with fiberglass insulation and provide fire retardant polyethylene or reinforced metalized protective vapor barrier as specified herein.

1. Duct pressure class up to and including 6” w.g.

   a) Fire retardant polyethylene vapor barrier

      1) ATCO 80 Series
      2) Flexmaster Type 5B
      3) JPL Type PR Series
      4) Thermaflex Type G-KM

   b) Reinforced metalized vapor barrier

      1) ATCO 30 Series
      2) Flexmaster Type 5M
      3) JPL Type MHP Series
      4) Thermaflex Type M-KE

2. Flexible ductwork shall have CPE liner with steel wire helix mechanically locked or permanently bonded to the liner.
3. Provide acoustical, fiberglass insulated duct with minimum R-value of R-6.0.

2.013 FLEXIBLE ELBOW ASSEMBLY

A. Manufacturers:

1. Build Right Products, FlexRight Elbow.
2. Flexible Technologies, Inc,, FlexFlow Elbow.
3. Titus, FlexRight.

B. General: At Contractors option, in lieu of rigid sheet metal elbows at connections to air inlets and outlets in concealed spaces, provide flexible elbow assembly to air devices requiring a 90 degree elbow connection.

C. Flexible elbow assembly shall be constructed of durable composite material and UL listed for use in return air plenums with a turning radius of not less than 3 inches.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Provide turning vanes, of same gauge as ductwork, rigidly fastened with guide strips in ductwork having an offset of 45 degrees or more. Provide vanes in all supply and exhaust ductwork and in return and outside air ductwork that has an air velocity exceeding 1000 fpm. Do not install vanes in grease or dryer exhaust ductwork.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Provide combination fire and smoke dampers, fire dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction.

1. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
2. Coordinate all smoke and fire/smoke damper installation, wiring, and checkout to ensure that the dampers function properly and that they respond to the proper fire alarm system signal.
3. Install ceiling radiation dampers per manufacturer’s instructions. Support damper assembly from structure.
4. Demonstrate re-setting of fire and fire/smoke dampers to Owner's representative.

E. Provide duct access doors to maintain and/or clean components internal to ductwork including, but not limited to, coils, airflow stations, motorized and backdraft dampers, humidifiers, etc, Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

1. Provide duct access door(s) as scheduled below, at each fire and smoke damper within 12 inches of the device to allow for testing and maintenance. Label each door (with minimum 1” lettering) indicating which damper type is served. Door shall be capable of being fully opened or provide removable door.

DUCT ACCESS DOOR SCHEDULE

Duct Width/Depth	Door Size	Quantity
10” TO 12”	10 X 10	1
14” TO 18”	12 X 12	1
20” TO 36”	14 X 14	1
38” TO 54”	18 X 18	1
56” TO 72”	18 X 18	2 (1 EACH END)
74” TO 96”	20 X 20	2 (1 EACH END)

2. Provide duct access doors for cleaning kitchen exhaust ducts in accordance with NFPA 96. Review locations prior to fabrication.

F. Provide flexible duct connections wherever ductwork connects to vibrating equipment and when transitioning between two different metallic duct materials (e.g., aluminum to galvanized steel). Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.

1. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
2. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

G. Provide volume control dampers at branch takeoffs from main ducts. Unless otherwise noted on drawings, provide prefabricated 45 degree, high efficiency, rectangular/round branch duct takeoff fittings with manual volume control damper and locking quadrant for branch duct connections and take-offs to individual diffusers, registers and grilles.

H. Provide cable operated volume dampers with remote operators where access to dampers through a hard ceiling is required.

1. Support cable assembly to avoid bends and kinks in cable.

I. Install grease exhaust and fire rated duct wrap in accordance with manufacturer's instructions to provide the fire rating of the material as tested per UL requirements. Joints at insulation seams, banding, pins, and fire stop systems shall be installed as per manufacturers UL Listing and manufacturers published installation instructions. Overlap seams, install stainless steel bands and/or pins to secure wrap to duct and fill annular spaces in floor and wall penetrations with UL rated forming materials and/or putty to maintain the integrity of the system.

J. Install flexible ductwork in accordance with manufacturer's instructions. At a minimum, install two wraps of duct tape around the inner core connection and a metallic or non-metallic clamp over the tape and two wraps of duct tape or a clamp over the outer jacket.

1. Flexible ductwork runs shall not exceed 5 feet in length. Utilize the minimum length of duct to make the connections.
2. Install flexible ductwork straight as possible avoiding tight turns with a maximum of one 90 degree bend in any length. Install flexible ductwork fully extended minimizing compression.
3. Provide continuous length with no intermediate joints.
4. Support flexible ductwork from structure and not from ceiling tile, light fixtures or air terminals. Support for maximum sag of 1/2-inch per foot.
5. Avoid incidental contact with metal fixtures, water lines, pipes, or conduit.
6. Support straps/saddles shall be minimum 1-1/4" wide. Use of wire hanging systems shall utilize strap and connect wire to strap.

   a) Factory installed suspension systems are acceptable

7. Do not crimp flexible ductwork against joist or truss members, pipes, conduits, etc.
8. Install flexible ductwork with bend radius at the center line equal to or greater than one duct diameter.

   a) Support bends approximately one duct diameter on both sides of bends.

9. Connect flexible ductwork to sheet metal ductwork and air devices with at least 1" overlap.

K. Provide rigid duct elbow or flexible elbow assembly where a 90 degree elbow is required at connection to air devices.

L. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.03 FIELD QUALITY CONTROL

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

B. After start-up, final corrections and balancing of systems, test duct silencers by taking octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed. Refer to Division 23 Section “Testing, Adjusting and Balancing of HVAC” for additional requirements.

1. Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.
2. Submit complete report of test results including sound curves.

3.04 ADJUSTING AND CLEANING

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

B. Label access doors in accordance with Division-23 section "Identification for HVAC Piping and Equipment".

C. Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting, and Balancing for HVAC".

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Tubeaxial fans.

B. Destratification fans.

C. Jet fans.

1.02 REFERENCE STANDARDS

A. AMCA 99 – Standards Handbook.

B. AMCA 204 – Balance Quality and Vibration Levels for Fans.

C. AMCA 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

D. AMCA 230 – Laboratory Methods of Testing Air Circulation Fans for Rating and Certification.

E. AMCA 300 – Reverberant Room method for Sound Testing of Fans.

F. AMCA 301 – Certified Ratings Program Product Rating manual for Fan Sound Performance.

G. AMCA 311 – Certified Ratings Program Product Rating Manual for Fan Sound Performance.

H. UL 705 – Power Ventilators; Current Edition Including all Revisions.

I. UL 762 – Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances; Current Edition Including all Revisions.

1.03 SUBMITTALS

A. General: Submit data in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements. Include the following:

1. For fans with factory-furnished starters or variable frequency drives, include short circuit current ratings.
2. Materials gages and finishes, including color charts.

3. Dampers, including housings, linkages, and operators.

C. Shop Drawings: Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

D. Wiring Diagrams: Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.

E. Maintenance Data: Include instructions for lubrication, motor and drive replacement and spare parts list.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Fan Belts: One set for each individual fan.

1.04 QUALITY ASSURANCE

A. AMCA Compliance:

1. Provide propeller, tubeaxial, vaneaxial and mixed flow fan products that meet performance requirements and are licensed to use the AMCA Seal.
2.
3. Testing Requirements: The following factory tests are required for propeller, tubeaxial, mixed flow and vaneaxial fans:

a) Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
b) Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

B. UL Compliance: Fans and components shall be UL listed and labeled.

1. Fans used in grease exhaust applications shall be certified in accordance with UL 762.

C. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

E. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.06 FIELD CONDITIONS

A. Permanent fans may not be used for ventilation during construction.

PART 2 - PRODUCTS AND MATERIALS

2.01 FANS, GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.5.

D. Belts: Oil-resistant, non-sparking, and non-static.

E. Motors: Refer to Section “Common Motor Requirements for HVAC Equipment” for requirements.

F. Motor and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide OSHA compliant steel belt guards for motors mounted on the outside of the fan cabinet.

G. Hazardous Duty: Provide fans with spark resistant construction and explosion proof motor where specified in the schedule.

2.02 TUBEAXIAL FANS

A. Manufacturers:

1. Bayley Fan Group.

2. Cook (Loren) Co.
3. Chicago Blower Corp.
4. Greenheck Fan Corp.
5. Hartzell Fan, Inc.
6. PennBarry.
7. Trane Co.
8. Twin City Fan Company.

B. Description: Belt-driven or direct-drive as indicated, tubeaxial fans consisting of fan wheel and housing, inlet/outlet cone section as indicated, factory-mounted motor, and accessories.

C. Casing:

1. Steel casing, 12-gage minimum.
2. Continuously weld, with flanged inlet and outlet connections, and motor or shaft supports.
3. Guide Vane Section: Integral guide vanes downstream of the fan wheel designed to straighten the airflow for fans specified for static pressures greater than 1 in-wc..

D. Propeller: Fixed pitch, one piece cast aluminum, axial-flow type, with airfoil-shaped blades keyed and secured to shaft with a split taper bushing and retaining plate.

E. Bearings and Drives:

1. Direct Drive: Encase motor in housing outside of airstream.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Lubrication: Extend lubrication lines to outside of casing and terminate with grease fittings.

F. Accessories:

1. Inlet Bell: Bell mouth inlet of same material as casing.
2. Outlet Cone: Transition of same material as casing with outlet area to inlet area ration of 1.5 to 1.0, with center pod as recommended by manufacturer.
3. Inlet Screens: Provide wire mesh screen of same material as casing where inlet is not connected to ductwork.
4. Outlet Screen: Wire-mesh screen of same material as casing, where outlet is not connected to ductwork.
5. Access Door: Bolted door of same material as casing to allow limited access to internal parts of fan including the bearing cover.
6. Swing-out Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as casing.
7. Mounting Feet: Feet bolted to the inlet and outlet flanges to facilitate mounting to the floor, ceiling, or wall that can be used with vibration isolators.

8. Mounting Brackets: Brackets welded in place to facilitate suspension of unit in either the vertical or horizontal configuration designed for use with vibration isolators.
9. Motor Cover: Cover of same material as casing, with side vents to dissipate motor heat.
10. Exterior Up-blast Discharge Assembly: Curb cap, motor cover, panel and butterfly dampers used in conjunction with a roof curb to utilize unit as a roof up-blast unit.

G. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Color-match enamel

    a) Apply to finished casings.
    b) Apply to fan wheels.

2.03 DESTRATIFICATION FANS

A. Manufacturers:

1. Air Pear
2. Air Row Fans
3. Canarm HVAC
4. Continental Fans
5. Zoo Fans

B. General Description: Small diameter housed propeller type destratification fans as indicated consisting of housing, fan blades, hub, mounting system, motor, and fan controller.

C. Housing: Fan housing shall be constructed from one of the following materials:

1. PC/ABS resin, UL 94 5VA flame resistance rating.
2. Steel with polymeric or corrosion-resistant coating.
3. Painted aluminum.

D. Housing Configuration:

1. Round shaped.

E. Fan Blades: PC/ABS resin or aluminum material with airfoil or axial design.

F. Motor and Frame: Electrically commutated, 92% efficient motor with 0-10 VDC control for tie-in to BAS. Provide thermally protected motor. Operating temperature range shall be -13˚ F (-25˚ C) to 140˚ F (60˚ C). Motor shall have sealed bearings with no lubrication required.

G. Mounting System and Location:

1. Overhead Structure: Designed for secure mounting of fan from overhead support structure. Mount shall be constructed of minimum 3/16” powder-coated steel. Provide minimum 1/4” 7x19 steel safety cable to secure fan assembly to structure.
2. Suspended Ceiling: Support fan from above structure with cable or wire capable of supporting 5 times the fan weight.

H. Fan Controller:

1. Industrial Control Panel constructed per UL 60950 and NEC.
2. Provide fan on/off/auto switch, speed control potentiometer, safety disconnect and properly sized fuse block.
3. Provide NEMA Type 1 controls enclosure for indoor installations and NEMA Type 3R controls enclosure for outdoor installations.
4. Fan controller shall be capable of full integration into the building automation system via Bacnet interface. Refer to the drawings for control sequences.

2.04 JET FANS

A. Manufacturers:

1. Greenheck Fan Corp.
2. Zoo Fans

B. General Description: High velocity, jet induction fan with aerodynamic housing and integral discharge vanes.

C. Housing: Fan housing and support structure shall be constructed of galvanized steel with polymeric or corrosion-resistant coating.

D. Housing Configuration:

1. Low flat profile.

E. Fan Impeller: Composite plastic or aluminum material for blades and wheel hub. Blades shall be axial or centrifugal configuration.

F. Motor and Frame: Squirrel cage induction motor with variable frequency drive or electrically commutated, 92% efficient motor with 0-10 VDC control for tie-in to BAS. Provide thermally protected motor. Operating temperature range shall be -13˚ F (-25˚ C) to 140˚ F (60˚ C).

1. Motors shall have sealed bearings with no lubrication required.
2. Motors with variable frequency drives shall have shaft grounding system.

G. Accessories: Provide the following accessories as scheduled or noted on the drawings:

1. Factory mounted disconnect switch.
2. Inlet and outlet guards.

PART 3 - EXECUTION

3.01 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of structural steel support members.

3.02 INSTALLATION

A. Install fans level and plumb, in accordance with manufacturer's written instructions.

B. Support units using the vibration control devices indicated and specified in Division 23 Section "Vibration Isolation for HVAC Piping and Equipment."

C. Arrange installation to provide access space around fans for service and maintenance.

D. Provide safety screen where inlet or outlet is exposed.

3.03 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.04 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.
2. Verify fan assembly is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
    a) Replace fan and motor pulleys as required to achieve design conditions.
    b) Measure and record motor electrical values for voltage and amperage.
    c) Shut unit down and reconnect automatic temperature control operators.
    d) Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for air-handling-system testing, adjusting, and balancing.

3.05 DEMONSTRATION

A. Demonstration Services: Train Owner's maintenance personnel on the following:
   1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
   2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Closeout Procedures" and Division 23 Section "General Mechanical Requirements."

B. Schedule training with at least 7 days' advance notice.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Roof ventilators.

B. Upblast roof exhausters.

C. Inline centrifugal fans.

D. Kitchen hood exhausters.

1.02 REFERENCE STANDARDS

A. AMCA 99 – Standards Handbook.

B. AMCA 204 – Balance Quality and Vibration Levels for Fans.

C. AMCA 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

D. AMCA 300 – Reverberant Room method for Sound Testing of Fans.

E. AMCA 301 – Certified Ratings Program Product Rating manual for Fan Sound Performance.

F. AMCA 311 – Certified Ratings Program Product Rating Manual for Fan Sound Performance.

G. NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

H. UL 705 – Power Ventilators; Current Edition Including all Revisions.

I. UL 762 – Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances; Current Edition Including all Revisions.

1.03 SUBMITTALS

A. General: Submit data in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements. Include the following:

1. For fans with factory-furnished starters or variable frequency drives, include short circuit current ratings.
2. Materials gages and finishes, including color charts.
3. Dampers, including housings, linkages, and operators.

C. Shop Drawings: Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

D. Wiring Diagrams: Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.

E. Maintenance Data: Include instructions for lubrication, motor and drive replacement and spare parts list.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Fan Belts: One set for each individual fan.

1.04 QUALITY ASSURANCE

A. AMCA Compliance: Provide products that meet AMCA certified performance and sound ratings and are licensed to use the AMCA Seal.

B. UL Compliance: Fans and fan motors shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators."

C. Kitchen Hood Exhaust Fans: Kitchen hood exhaust fans and components shall comply with requirements of UL 762 and NFPA 96.

D. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

E. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.06 FIELD CONDITIONS

A. Permanent fans may not be used for ventilation during construction.

PART 2 - PRODUCTS AND MATERIALS

2.01 POWER VENTILATORS - GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished; with indicated capacities and characteristics.

B. Statically and Dynamically Balanced: Fans and shafts shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210.

D. Sound Ratings: Comply with AMCA 301. Test fans in accordance with AMCA Standard 300.

E. Fabrication: Comply with AMCA 99.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.4.

G. Belts: Oil-resistant, non-sparking, and non-static.

H. Motors: Refer to Section "Common Motor Requirements for HVAC Equipment" for requirements.

I. Motor and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

J. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.

2.02 ROOF VENTILATORS

A. Manufacturers:

1. Accurex.
2. Acme Engrg. & Mfg. Corp.
3. CaptiveAire
4. Carnes Company, Inc.
5. Cook (Loren) Co.
6. Greenheck Fan Corp.
7. Hartzell Fan, Inc.
8. PennBarry.
9. Twin City Fan Company.

B. Fan Unit: Belt-driven or direct-drive as indicated, centrifugal or axial fan, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

D. Roof Curbs: Refer to Section "Hangers and Supports for HVAC" for pre-engineered roof equipment supports .

E. Fan Wheel: Aluminum hub and wheel.

F. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
4. For centrifugal fans, fan and motor shall be isolated from exhaust air stream.

G. Accessories: Provide the following items as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
2. Bird Screens: Maximum 1/2-inch mesh, 16-gage, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.
4. Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.

a) Blades: Die-formed sheet aluminum.
b) Frame: Extruded aluminum, with waterproof, felt blade seals.
c) Linkage: Nonferrous metals, connecting blades to counter weight or operator.
d) Operators: Manufacturer's standard electric actuator.
e) Operators: Manufacturer's standard pneumatic actuator.

2.03 UPBLAST ROOF EXHAUSTERS

A. Manufacturers:

1. Accurex.
2. Acme Engrg. & Mfg. Corp.
3. CaptiveAire
4. Carnes Company, Inc.
5. Cook (Loren) Co.
6. Greenheck Fan Corp.
7. Hartzell Fan, Inc.
8. PennBarry.

9. Twin City Fan Company

B. General Description: Belt-driven or direct-drive as indicated, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Fan Wheel:

1. Type: Non-overloading centrifugal, propeller or axial blades as scheduled
2. Material: Aluminum ,

D. Housing:

1. Construct of heavy-gage aluminum including curb cap, windband and motor compartment..
2. Rigid internal support structure.
3. One-piece fabricated or fully welded curb-cap to windband for leak proof construction.
4. Wind Band and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

   a) Dampers Rods: Steel with bronze or nylon bearings.

5. Provide breather tube for fresh air motor cooling and wiring.

E. Shafts and Bearings:

1. Fan Shaft:

   a) Ground and polished steel with anti-corrosive coating.
   b) First critical speed at least 25 percent over maximum cataloged operating speed.

2. Bearings

   a) Permanently sealed or pillow block type.
   b) Minimum L10 life in excess of 50,000 hours.

F. Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
2. Belts: Static free and oil resistant.
3. Pulleys: Cast-iron, adjustable-pitch, keyed and securely attached to the wheel and motor shafts..

G. Roof Curbs: Refer to Section “Hangers and Supports for HVAC” for pre-engineered roof equipment supports.

H. Drain Trough: Provides single point drainage for water or other residue.

I. Accessories: Provide the following items as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
2. Bird Screens: Maximum 1/2-inch mesh, 16-gage aluminum or brass wire.
3. Dampers: Counter-balanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.

    a) Blades: Die-formed sheet aluminum.
    b) Frame: Extruded aluminum, with waterproof, felt blade bumpers.
    c) Linkage: Nonferrous metals.
    d) Operators: Manufacturer's standard electric actuator.
    e) Operators: Manufacturer's standard pneumatic actuator.

5. Hinge Kits:

    a) Aluminum hinges.
    b) Hinges and restraint cables mounted to the base.
    c) Allows fan to tilt away for access to wheel for inspection and cleaning.

2.04 INLINE CENTRIFUGAL FANS

A. Manufacturers:

1. Acme Engrg. & Mfg. Corp.
2. CaptiveAire
3. Carnes Company, Inc.
4. Cook (Loren) Co.
5. Greenheck Fan Corp.
6. PennBarry.
7. Twin City Fan Company

B. Fan Unit: Inline, belt or direct driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.

C. Housing: Galvanized steel or split, spun-aluminum housing, with straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Wheel: Aluminum, forward curved, backward inclined or airfoil blades welded to aluminum hub.

E. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

F. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing. Provide self-aligning pre-lubricated ball bearings.

G. Accessories: Provide the following accessories as indicated:

1. Volume Control Damper: Manual operated with quadrant lock, located in fan outlet.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: Expanded metal in removable frame.
4. Speed Control: Variable speed switch with on-off control and speed control for 100 to 50 percent of fan air delivery.

2.05 KITCHEN HOOD UPBLAST EXHAUSTERS

A. Manufacturers:

1. Accurex.
2. CaptiveAire
3. Carnes Company, Inc.
4. Cook (Loren) Co.
5. Greenheck Fan Corp.
6. PennBarry.
7. Twin City Fan Company

B. Fan Unit: Belt-driven or direct-drive as indicated, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing:

1. Construct of heavy-gage, removable, spun-aluminum including curb cap, windband and motor compartment.

2. Rigid internal support structure.
3. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
4. Construct drive frame assembly of heavy gauge steel, mounted on vibration isolators.
5. Provide breather tube for fresh air motor cooling and wiring.

D. Fan Wheel: Aluminum hub and blades.

E. Shafts and Bearings:

1. Fan Shaft:

a) Ground and polished steel with anti-corrosive coating.
b) First critical speed at least 25 percent over maximum cataloged operating speed.

2. Bearings

a) Permanently sealed or pillow block type.
b) Minimum L10 life in excess of 50,000 hours.

F. Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
2. Pulleys: Cast-iron, adjustable-pitch, keyed and securely attached to the wheel and motor shafts..

G. Grease Exhaust: Exhaust fans serving Type I kitchen exhaust hoods shall discharge a minimum of 40” above the roof surface, shall have hinged access, shall have access opening on curvature of outer housing for blade inspection and cleaning, and shall be installed in accordance with NFPA 96 and local codes.

H. Roof Curbs: Refer to Section “Hangers and Supports for HVAC” for pre-engineered roof equipment supports

I. Drain Trough: Grease drain trough shall be filled with replaceable, absorbent material or replaceable cup with absorbent material and cap which absorbs grease and rejects water.

J. Accessories: Provide the following items as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
2. Clean Out Port: Removable grease repellent compression rubber plug allows access for cleaning wheel through windband.
3. Roof Curb Extension: Vented curb extension where required for compliance with minimum clearances required by NFPA 96.
4. Hinge Kit:

    a) Aluminum hinges.
    b) Hinges and restraint cables mounted to base (sleeve).
    c) Allows fan to tilt away for access to wheel and ductwork for inspection and cleaning.

5. Heat Baffle: Prevents heat from radiating into motor compartment.

PART 3 - EXECUTION

3.01 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of structural steel support members.

3.02 INSTALLATION

A. Install fans level and plumb, in accordance with manufacturer's written instructions.

B. Secure roof-mounted fans to pre-engineered roof equipment supports in accordance with the requirements specified in Section “Hangers and Supports for HVAC Piping and Equipment.”

C. Cabinet Units: Suspend units from structural steel support frame using steel wire or metal straps.

D. Install vibration isolation for equipment as specified in Division 23 Section “Vibration Isolation for HVAC Piping and Equipment.”

E. Arrange installation to provide access space around fans for service and maintenance.

3.03 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.04 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.
2. Verify fan assembly is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

    a) Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.
3. Shut unit down and reconnect automatic temperature control operators.
4. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for air-handling-system testing, adjusting, and balancing.

3.05 DEMONSTRATION

A. Demonstration Services: Train Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Closeout Procedures" and Division 23 Section "General Mechanical Requirements."

B. Schedule training with at least 7 days' advance notice.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Variable Air Volume Terminal Units

1. Reheat

1.02 REFERENCE STANDARDS

A. AHRI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils.

B. AHRI 880 – Performance Rating of Air Terminals.

C. AHRI 885 – Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

D. ASHRAE Std 130 – Methods of Testing Air Terminal Units.

E. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.

F. UL 181 – Standard for Factory-Made Air Ducts and Air Connectors.

G. UL 94 – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; certified sound power data for each unit; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components and electrical characteristics and connection requirements.

C. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.

D. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

E. Nameplate Data: Nameplate data shall be submitted in a timely manner so as to allow proper coordination with the Electrical Contractor. Submittals that do not have nameplate data will be rejected.

F. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.

G. Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.

H. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Division 1.

1.04 QUALITY ASSURANCE

A. ADC Compliance: Provide air terminals which have been tested and rated in accordance with ADC standards, and bear ADC Seal.

B. UL/ETL Compliance: Air terminal units shall be UL or ETL listed as a complete assembly. All electrical components shall be UL listed and installed in accordance with the National Electric Code.

C. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.05 SPARE PARTS

A. If HVAC equipment is used during construction, the contractor is fully responsible for it’s cleaning just before substantial completion prior to testing and balancing.

PART 2 - PRODUCTS

2.01 VARIABLE AND CONSTANT AIR VOLUME TERMINAL UNITS

A. Manufacturers:

1. Carnes Co.
2. Carrier Corp.; Sub. of United Technologies Corp.
3. Environmental Technologies, Inc.
4. Johnson Controls, Inc.
5. Krueger Mfg. Co.
6. Metalaire.
7. Nailor Industries, Inc.
8. Price Industries.
9. Tempmaster Corp.
10. Titus Products Div.; Philips Industries, Inc.
11. Trane (The) Co.

B. Construction

1. Casings: Construct of galvanized sheet metal of minimum 22 gauge thickness or die-cast aluminum of minimum 20 gauge thickness.

   a) Assembled with longitudinal lock seam construction.
   b) Construct casings such that when subjected to 0.5-in w.g. pressure for low pressure units, and 3.0-in w.g. pressure for high pressure units, total leakage does not exceed 2% of specified air flow capacity with outlets sealed and inlets wide open.

2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes or rectangular where needed to meet airflow requirements.
3. Unit Discharge: Rectangular, with slip-and-drive connections.
4. Acceptable Liners:

   a) Linings: Line inside surfaces of casings with fiberglass, lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1/2". Secure lining to prevent delamination, sagging, or settling.
   b) Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1/2". Lining shall be closed cell foam and comply with UL 181 and NFPA 90A. Insulation shall be 1-1/2 lb. density.

Insulation shall be equivalent to Titus Fibre-Free Liner. Refer to Drawings for terminal units noted with this liner.

5. Access: Provide removable panels in casings to permit access to air dampers, fans and other parts requiring service, adjusting, or maintenance.

    a) Provide airtight gasket and quarter-turn latches.

6. Provide hanger brackets for attachment of supports.

C. Sound Attenuator

1. Provide if required to meet scheduled acoustical performance requirements.
2. Construction to consist of a continuous extension of the casing and liner as required to achieve required attenuation.
3. At 2000 fpm inlet velocity, the additional differential pressure drop with attenuator not to exceed 0.2 inch wg.
4. All sound data shall be compiled in an independent ADC certified laboratory and in accordance with the latest version of AHRI 880. All units shall be AHRI certified and bear the AHRI certification label.

D. Primary Air Damper Assembly

1. Heavy-gauge, galvanized steel or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
3. Incorporate low leak damper blades for tight airflow shutoff.

    a) Air Leakage Past Closed Damper: Maximum two percent of unit maximum airflow at 3 inch wg inlet static pressure, tested in accordance with ASHRAE Std 130.

E. Hot Water Heating Coil:

1. Seamless copper tubes, mechanically expanded into aluminum or aluminum-plated fins.
2. Include low-leakage access door for coil inspection and cleaning.
3. Coil leak tested to minimum 200 psig.
4. Base performance data on tests run in accordance with AHRI 410.

F. Electrical Requirements:

1. Single-point power connection.
2. Equipment wiring to comply with requirements of NFPA 70.
3. All electrical components shall be UL or ETL listed or recognized and installed in accordance with the National Electrical Code.

4. All electrical components shall be mounted in a control box.
5. The entire assembly shall be UL or ETL listed (cETL in Canada) and so labeled.

G. Control Transformers: Factory supplied and mounted for electric and electronic control applications.

H. Controls: Provide controls accurate to 1.5 degrees F and adjustable from 65 degrees F to 85 degrees F. Provide air flow measurement station at terminal unit inlet. Provide control type as indicated below.

1. DDC (Direct Digital Control): Provide direct digital controls, compatible with direct digital control system specified in other Division 23 sections.

a) The unit level controller to include the following:

1) 24 VAC power terminal or RJ-12 Power connection.
2) Port for thermostat connection.
3) Service Port for diagnostic equipment.
4) Damper actuator.
5) LED indication for troubleshooting.
6) Heating output signal(s).
7) Cooling output signal(s).
8) Supply air temperature sensor input.
9) Contact closure input.
10) BACNET communication capability.

b) Include a factory-installed, unit-mounted direct-digital controller.
c) Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
d) Microprocessor-Based Controller: Air volume controller, pressure-independent with electronic airflow transducers, factory-calibrated maximum and minimum CFM's.

1) Occupied and unoccupied operating mode.
2) Remote reset of temperature or CFM set points.
3) Proportional, plus integral control of room temperature.
4) Monitoring and adjusting with portable terminal.
5) Time-proportional reheat coil control.

e) Room Sensor:

1) Compatible with temperature controls specified.
2) Wall-mounted, system powered, with temperature set-point adjustment including connection access for portable operator terminal.

2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.

a) Sensor Requirements:

1) Plastic parts shall be fire-resistant, complying with UL 94.
2) Control tubing shall be protected by grommets at the wall of the air flow sensor's housing.
3) Furnished with multiple total and static pressure sensing ports and a center averaging chamber that amplifies the sensed air flow signal.
4) Provide sensor with a pressure transducer to interface with the building control system.

b) Signal accuracy: Provide accuracy within 5 percent throughout the terminal unit operating range.

I. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory-setting, and calibration curve (if required).

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that conditions are suitable for installation.

B. Verify that field measurements are as indicated on drawings.

3.02 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.

B. Install the inlets of air terminal units and air flow sensors a minimum of three duct diameters from elbows, transitions, and duct takeoffs.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to scheduled minimum flow.

3.04 FIELD QUALITY CONTROL

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, duct connections to air terminals, and water coils are leak-tight.

1. Leak Test:

a) Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.
b) Repair water leaks and retest until no leaks exist.

2. Operational Test:

a) After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
b) Test and adjust controls and safeties.
c) Replace damaged and malfunctioning controls and other equipment.

3.05 CLEANING

A. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

B. Install new filters.

END OF SECTION

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PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Gravity ventilators.

1. Louvered Penthouse

1.02 REFERENCE STANDARDS

A. AMCA 511 – Certified Ratings Program for Air Control Devices.

B. AMCA 550 – Test Method for High Velocity Wind riven Rain Resistant Louvers.

C. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets,

D. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for HVAC gravity ventilators including the following:

1. Schedule of HVAC gravity ventilators indicating drawing designation, number furnished, model number, size, and accessories furnished.
2. Data sheet for each type of HVAC gravity ventilator, and accessory furnished; indicating construction, finish, and mounting details.
3. Performance data for each type of HVAC gravity ventilator furnished, including pressure loss and noise criteria ratings at specified airflows. Indicate selections on data.
4. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of HVAC gravity ventilator, indicating materials and methods of assembly of components.
5. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

B. Coordination Drawings: Roof plans drawn to scale to show locations and coordination of HVAC gravity ventilators with other items installed on roof.

1.04 QUALITY ASSURANCE

A. ASHRAE Compliance: Test and rate HVAC gravity ventilators in accordance with ASHRAE 70.

B. AMCA Compliance: Performance ratings and factory testing of gravity ventilators to be in accordance with AMCA 511 and AMCA 550.

C. NFPA Compliance: Install HVAC gravity ventilators in accordance with NFPA 90A.

PART 2 - PRODUCTS

2.01 GRAVITY VENTILATORS

A. Manufacturers:

1. Acme.
2. Carnes Company, Inc.
3. Cesco.
4. Cook (Loren) Co.
5. Greenheck Fan Corp.
6. Nailor Industries, Inc.
7. PennBarry.
8. RuppAir Management Systems.
9. Vent Products.

B. Extruded Aluminum Louvered Ventilator:

1. Construction:

   a) Extruded aluminum louvers, minimum 0.081 inch thick, mitered at corners and welded for maximum strength.
   b) Removable Hood: Minimum 0.05 inch, reinforced and braced for extra strength.
   c) Base: 0.08 inch aluminum with mitered corners and seams with continuous weld for strength and tightness.

2. Options/Accessories:

a) Roof Curb: Prefabricated, heavy-gage, galvanized steel or aluminum roof curb with mitered and welded corners and 2-inch treated wood nailer.

1) Provide 1-1/2-inch-thick, 3 pound density, rigid, fiberglass insulation adhered to inside walls.
2) Welded, straight side curb with mounting flange.

b) Dampers:

1) Type: Backdraft or motorized damper as scheduled on the drawings.
2) Balanced for minimal resistance to flow.
3) Galvanized frames with pre-punched mounting holes.

c) Screens:

1) Fabricate in accordance with ASTM B221.
2) Birdscreen: Construct of 1/2 inch galvanized steel or aluminum mesh.
3) Insect Screen: Construct of fine mesh aluminum.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which HVAC gravity ventilators are to be installed for compliance with installation tolerances and conditions that would affect the performance of the equipment. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General: Install HVAC gravity ventilators in accordance with manufacturer's written instructions, design drawings, referenced standards, and in accordance with recognized industry practices to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, to interface installation of HVAC gravity ventilators with other work.

C. Locate HVAC gravity ventilators and goosenecks as indicated on the drawings. Adjust location to suit structural conditions.

3.03 CLEANING

A. After installation of HVAC gravity ventilators, inspect exposed finish. Clean exposed surfaces to remove dirt and smudges. Replace any HVAC gravity ventilator that has damaged finishes.

END OF SECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Replaceable (throwaway) extended area pleated filters.

B. Disposable, extended area pleated filters.

C. Disposable panel filters.

D. Washable permanent panel filters.

E. Filter fames and housings.

F. Filter Gauges

1.02 REFERENCE STANDARDS

A. AHRI 850 – Performance Rating of Commercial and Industrial Air Filter Equipment.

B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

C. IEST Recommended Practice RP-CC034: HEPA and ULPA Filter Leak Tests.

D. ISO Standard 29463: New Test Standard for HEPA Filters.

E. MIL-STD-282 - Filter Units, Protective Clothing, Gas-Mask Components, and Related Products: Performance-Test Methods.

F. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems

G. NFPA 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

H. UL 586 - High Efficiency, Particulate, Air Filter Units; Current Edition, Including All Revisions.

I. UL 900 - Standard for Air Filter Units; Current Edition, Including All Revisions

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data including, dimensions, weights, required clearances and access, flow capacity including initial and final pressure drop at rated air flow, efficiency and test method, fire classification, and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for filter rack assemblies indicating dimensions, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of filter and rack required. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.04 QUALITY ASSURANCE

A. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B, and NEC pertaining to installation of air filters and associated electric wiring and equipment.

B. UL Compliance:

1. Comply with UL Standards pertaining to safety performance of air filter units.

C. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

D. AHRI Compliance: Comply with provisions of AHRI Standard 850 pertaining to test and performance of air filter units.

1.05 SPARE PARTS

A. If HVAC equipment is used during the construction period, Contractor shall provide one set of filters (if system is designed to include pre-filters and after-filters, provide only pre-filters) when the unit is started and replace filters when needed, but not less than every month. On the day of substantial completion, the Contractor shall clean the unit and provide a new set of filters at each location in the unit.

PART 2 - PRODUCTS AND MATERIALS

2.01 REPLACEABLE (THROWAWAY), EXTENDED AREA PLEATED FILTERS

A. Manufacturers:

1. AAF/Flanders.
2. Bioclimatic Air Systems
3. Columbus Industries, Inc..
4. Camfil Farr.
5. Filtration Group
6. Koch Filter Corp.
7. Research Products Corp.

B. Media: UL 900 Class 2, pleated, lofted, non-woven, reinforced cotton and synthetic fabric; supported and bonded to welded wire grid. Wire grid shall be of non-corrosive metal or metal coated with rust inhibitor.

1. Frames: Minimum 20 gauge galvanized steel.
2. Gaskets: Provide gaskets to prevent unfiltered air by-passing between media frames and holding members.
3. Nominal Thickness: 1, 2 or 4 inch as noted on the drawings.

C. Minimum Efficiency Reporting Value (MERV): Provide filters with MERV 6, 8 or 13 rating as scheduled on the drawings. Testing shall be in accordance with ASHRAE Std 52.2.

D. Rating per ASHRAE 52.2:

1. MERV 6 filters: At 500 fpm, maximum initial resistance of 0.3” WG and final resistance of 0.9” WG.
2. MERV 8 filters: At 350 fpm for 1 inch filters and 500 fpm for 2 inch and 4 inch filters, maximum initial resistance of 0.3 inch WG and final resistance of 0.9 inch WG.
3. MERV 13 filters: At 350 fpm for 1 inch filters and 500 fpm for 2 inch and 4 inch filters, maximum initial resistance of 0.41 inch WG and final resistance of 0.9 inch WG.

2.02 DISPOSABLE, EXTENDED AREA PLEATED FILTERS

A. Manufacturers:

1. AAF/Flanders.
2. Bioclimatic Air Systems

3. Columbus Industries, Inc..
4. Camfil Farr.
5. Filtration Group
6. Koch Filter Corp.
7. Research Products Corp.

B. Media: UL 900 Class 2, pleated, synthetic fabric or fine, glass fiber; supported and bonded to welded wire grid. Wire grid shall be of non-corrosive metal or metal coated with rust inhibitor. Provide metal contour stabilizers where required by manufacturer for adequate support.

1. Frames: Minimum 20 gauge galvanized steel.
2. Gaskets: Provide gaskets to prevent unfiltered air by-passing between media frames and holding members.
3. Nominal Thickness: 2, 4, 6 or 12 inch as noted on the drawings.

C. Minimum Efficiency Reporting Value (MERV): Provide filters with MERV 9, 11, 13 or 14 rating as scheduled on the drawings. Testing shall be in accordance with ASHRAE Std 52.2.

D. Rating per ASHRAE 52.2:

1. MERV 9 filters: For 2 inch and 4 inch filters, at 500 fpm, maximum initial resistance of 0.30 inch WG and final resistance of 1.0 inch WG. For 6 inch filters at 300 FPM, maximum initial resistance of 0.2 inch WG and final resistance of 1.5 inch WG. For 12 inch filters at 500 FPM, maximum initial resistance of 0.4 inch WG and final resistance of 1.5 inch WG.
2. MERV 11 filters: For 2 inch and 4 inch filters, at 500 fpm, maximum initial resistance of 0.50 inch WG and final resistance of 1.0 inch WG. For 6 inch filters at 300 FPM, maximum initial resistance of 0.2 inch WG and final resistance of 1.5 inch WG. For 12 inch filters at 500 FPM, maximum initial resistance of 0.35 inch WG and final resistance of 1.5 inch WG.
3. MERV 13 filters: For 2 inch and 4 inch filters, at 500 fpm, maximum initial resistance of 0.50 inch WG and final resistance of 1.0 inch WG. For 6 inch filters at 300 FPM, maximum initial resistance of 0.45 inch WG and final resistance of 1.5 inch WG. For 12 inch filters at 500 FPM, maximum initial resistance of 0.45 inch WG and final resistance of 1.5 inch WG.

2.03 DISPOSABLE PANEL FILTERS

A. Manufacturers:

1. AAF/Flanders.
2. Bioclimatic Air Systems
3. Columbus Industries, Inc..

4. Camfil Farr.
5. Filtration Group
6. Koch Filter Corp.
7. Research Products Corp.

B. Media: UL 900 Class 2, interlaced glass fibers, sprayed with non-flammable, non-drip, non-volatile adhesive.

1. Casing: Carboard frame.
2. Nominal Thickness: 1 or 2 inch as noted on the drawings.

C. Minimum Efficiency Reporting Value (MERV): Provide filters with MERV 4 rating. Testing shall be in accordance with ASHRAE Std 52.2.

D. Rating per ASHRAE 52.2: At 500 FPM, maximum initial resistance of 0.15 inch WG and final resistance of 0.50 inch WG.

E. Holding Frames: 20 gauge, 0.0359 inch minimum galvanized steel frame with expanded metal grid on outlet side and steel rod grid on inlet side, hinged with pull and retaining handles.

1. Gaskets: Provide gaskets to prevent unfiltered air by-passing between media frames and holding members.

2.04 WASHABLE PERMANENT PANEL FILTERS

A. Manufacturers:

1. Air Filters Inc.
2. Columbus Industries, Inc..
3. Camfil Farr.
4. Koch Filter Corp.
5. Research Products Corp.
6. Smith Filter Corporation.

B. Media: Flat panel, cleanable, 14 mesh screen constructed of aluminum or galvanized steel layered of flat and herringbone crimp.

1. Frame: Aluminum or galvanized steel header frame.
2. Thickness: 1 or 2 inch.

C. Minimum Efficiency Reporting Value (MERV): Provide filters with MERV 3 rating. Testing shall be in accordance with ASHRAE Std 52.2.

D. Performance Rating:

1. Initial resistance at 300 FPM face velocity: 0.03 inch WG for 1” thick and 0.05” WG for 2” thick.
2. Recommended Final Resistance at 300 FPM face velocity: 0.50 inch WG.

2.05 FILTER FRAMES AND HOUSING

A. Manufacturers:

1. AAF/Flanders.
2. Columbus Industries, Inc..
3. Camfil Farr.
4. Filtration Group
5. Koch Filter Corp.

B. General: Fabricate filter frames and supporting structures of minimum 16 gauge galvanized steel or extruded aluminum framing members having minimum thickness of 0.09". Design housing system for either upstream (front) or downstream (rear) filter servicing. Provide permanently gasketed framing members to prevent bypass of unfiltered air. If vertical support members are required to prevent deflection of horizontal members, install so as not to interfere with either installation or operation of filters. Incorporate separate track for prefilters, removable from front, or removable from back after removal of after-filters. Provide factory-installed positive sealing device for each row of filters, to ensure seal between gasketed filter elements. Provide hardware necessary for field assembly.

C. Standard Sizes: Provide frame and housing of size and capacity for filter media to meet the maximum velocity as scheduled or noted on drawings.

D. Side Servicing Housings: Flanged for insertion into ductwork constructed of minimum 16 gauge galvanized steel with aluminum tracks or channels for filter banks specified on the drawings. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass. Arrange so filter cartridge can be loaded from either access door.

2.06 FILTER GAUGES

A. Manufacturers:

1. Dwyer Instruments, inc.
2. H.O. Trerice co.

3. Weiss Instruments
4. Wika USA

B. General: Provide separate gauge for each filter bank or gauge with sufficient range to serve all connected filters.

C. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range such that final filter pressure drop is near mid-range, 2 percent of full scale accuracy.

D. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum, plastic or copper tubing, 2- or 3-way vent valves, and mounting bracket.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer’s instructions and comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.

B. Install air filters and holding devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes.

C. Locate each filter unit accurately in position indicated, in relation to other work. Position unit with sufficient clearance for normal service and maintenance. Anchor filter holding frames securely to substrate.

D. Coordinate with other work including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.

E. Install filters in proper position to prevent passage of unfiltered air.

F. Install air filter gauge pressure tips upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gauges if any, for proper readings.

3.02 FIELD QUALITY CONTROL

A. Cleaning:

1. Thoroughly clean any equipment that has been operated during the construction period.
2. Replace filters in any equipment that has operated during the construction period or that got dirty from the construction process.

END OF SECTION