

SECTION 230000 - HEATING, VENTILATING AND AIR-CONDITIONING (HVAC)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section of the specifications shall be applicable to all phases of mechanical work covered by specifications and drawings issued for this project.
- B. The "General Conditions of the Contract", "Supplementary General Conditions", and all other similar general requirements issued for this project shall apply to all mechanical work and are hereby made a part of this section.
- C. The Contractor and/or his representatives shall be fully acquainted with the design and operation of the systems and equipment described in these specifications and on the drawings.
- D. Work included under this section shall include complete systems as shown on the plans and as specified. Provide supervision, labor, material, equipment, machinery, plant, and other items necessary to complete the mechanical systems. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation.
- E. Definitions:
  - 1. "Owner" and "Contractor" shall mean the respective parties to the prime contract governing the project. Only one contractor is recognized as a party to this contract. Where the terms "Mechanical Contractor" or "Subcontractor" are used, it is for convenience only.
  - 2. "Architect/Engineer" shall mean the firm and authorized representatives of the firm engaged by the Owner for architectural and engineering services related to this project.
  - 3. "Mechanical" shall mean all work related to air conditioning, heating, ventilation, plumbing, sprinkler systems, noise and vibration control, and similar work, including all related components, accessories, controls, and miscellaneous work required for a complete system.
  - 4. "Contract Documents" shall mean and include the agreement, the drawings and specifications and all modifications thereto authorized by the Owner in writing prior to final completion of the project.
    - a. The term "Agreement" shall mean the completed and signed contract form.
    - b. The term "Drawings" shall mean the drawings prepared by the Architect/Engineer for specific use in bidding and execution of the work.
    - c. The term "Specifications" shall include the legal and procedural documents, the general conditions, special conditions, and the technical specifications.
    - d. The term "Technical Specifications" shall mean that part of the specifications which describes, outlines, and stipulates the kind and quality of the materials to be furnished, the quality of workmanship required, and the methods to be used in the construction under the contract. For convenience, the mechanical portions of the technical specifications are arranged into one general section and several detailed sections related to the various trades represented in the work. Such arrangement and references shall not operate to make the Architect/Engineer an arbiter in establishing the limits of any subcontract or trade.

5. "Work" of the Contractor shall mean labor or materials or both.
6. "As shown", "as indicated", "as detailed", or words of similar import shall mean reference to the drawings included in the contract documents, unless stated otherwise.
7. "As directed", "as required", "as permitted", "approved", or words of similar import shall mean that the direction, requirement, permission, approval, or acceptance of the Architect/Engineer is intended unless stated otherwise.
8. "As necessary" shall mean that which is necessary to achieve satisfactory completion of the work in order to provide the intended function and form of the project in compliance with the contract documents.
9. "Provide" shall mean "provide complete and in place", that is "furnish and install", ready for beneficial occupancy by the Owner. Except where stated otherwise, description of any work in the contract documents shall mean that the work shall be provided by the Contractor, even though the words "provide" or "furnish and install" do not accompany the description.
10. "Similar" shall be interpreted in a general sense and not as meaning identical, and all related details shall be worked out in respect to their location and their connection with other parts of the work.
11. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
12. Option or Optional: Contractor's choice of an alternate material or method.

## 1.2 INTENT OF CONTRACT DOCUMENTS

- A. The contract documents are complementary, and what is called for in one place shall be as binding as if called for in all places. Where variances occur between drawings and specifications or within either document itself, include in the contract price the item or arrangement of better quality, greater quantity, or higher cost. Agreement shall take precedence over the specifications and drawings. Figured dimensions shall be used in preference to scaling the drawings. In case of conflict between large and small scale drawings, the large scale drawings shall govern.
- B. The mechanical drawings show the general arrangement of all piping, equipment, and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. The mechanical work shall conform to the requirements shown on all of the drawings. Architectural and structural drawings shall take precedence over mechanical drawings. Because of the small scale of the mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, boxes, offsets, transitions, and other accessories as may be required to meet such conditions.

## 1.3 CODES AND STANDARDS

- A. All materials and workmanship shall comply with all applicable codes, state and federal laws, local ordinances, industry standards, utility company regulations, and all other criteria which normally apply to work of this nature.
- B. In case of difference between building codes, state laws, federal laws, local ordinances, industry standards, utility company regulations, other criteria and the contract documents, the more stringent regulations will apply. The Contractor shall promptly notify the Architect/Engineer in writing of any such difference.

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- C. If the Contractor performs any work that does not comply with these contract documents or the requirements of the applicable building codes, state laws, local ordinances, industry standards, utility company regulations, and other applicable criteria, he shall bear all costs arising in correcting the deficiencies.
- D. The standards referred to, except as modified in the specifications, shall have full force and effect as though printed in these specifications. The manufacturer and trades involved shall be familiar with the application of these standards.
- E. Applicable codes and standards shall include, but are not necessarily restricted to, the most recently recognized issues of the following:
1. Building Codes:
    - a. Virginia Uniform Statewide Building Code
    - b. International Mechanical Code and accumulative supplements.
  2. Industry Standards, Codes, and Specifications:
    - a. AASHO - American Association of State Highway Officials
    - b. ADA - Americans with Disabilities Act
    - c. AGA - American Gas Association
    - d. ARI - Air Conditioning and Refrigeration Institute
    - e. AMCA- Air Moving and Conditioning Association
    - f. ANSI - American National Standards Institute
    - g. ASHRAE - American Society of Heating, Refrigeration, and Air Conditioning Engineers
    - h. ASME - American Society of Mechanical Engineers
    - i. ASSE - American Society of Sanitary Engineering
    - j. ASTM - American Society of Testing and Materials
    - k. AWS - American Welding Society
    - l. CISPI - Cast Iron Soil Pipe Institute
    - m. CSA - Canadian Standards Association
    - n. AWWA- American Water Works Association
    - o. FIA - Factory Insurance Association
    - p. FM - Factory Mutual
    - q. FS - Federal Specification
    - r. IBR - Institute of Boiler and Radiator Manufacturers
    - s. IRI - Industrial Risk Insurers
    - t. ISO - Insurance Services Office
    - u. MSS - Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc.
    - v. NBS - National Bureau of Standards
    - w. NEC - National Electrical Code
    - x. NFPA - National Fire Protection Association
    - y. NSF - National Sanitation Foundation
    - z. PDI - Plumbing & Drainage Institute
    - aa. UL - Underwriters' Laboratories, Inc.
    - bb. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association
    - cc. UFAC - Uniform Federal Accessibility Standards
    - dd. SCAQMD - South Coast Air Quality Management District
    - ee. GS - Green Seal Standard

1.4 GOVERNMENTAL FEES, PERMITS, AND INSPECTIONS

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall obtain and pay for all required licenses, permits, charges for connections to outside services, fees and inspections. Upon completion of the work under each section of the detailed mechanical specifications, the Contractor shall furnish a certificate of final inspection to the Architect/Engineer from the governmental inspection department having jurisdiction.

1.5 VISITING THE SITE

- A. Each Contractor shall be responsible for visiting the site before bidding the job to familiarize himself with all existing conditions to be met in the execution of the work under this contract. No additional compensation will be allowed for any changes which may be required to make because of site conditions.

1.6 QUALITY ASSURANCE

- A. Product Criteria:
1. All materials shall be new and shall bear the manufacturer's name, trade name, and the UL label in every case where a standard has been established for this particular material. The equipment to be furnished shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design. All equipment shall bear a permanent and legible factory-applied nameplate to permit identification of manufacturer, model number and type of unit.
  2. Equipment Service: Products shall be supported by a service organization which maintains an adequate inventory of repair parts and is located, in the opinion of the Architect/Engineer, reasonably close to the site.
  3. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer to provide for uniform appearance, operation, and maintenance.
  4. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
- B. Manufacturers' directions shall be followed in the delivery, storage, protection, and installation of all equipment and materials. The Contractor shall promptly notify the Architect/Engineer in writing of any conflict between any requirements of the contract documents and the written instructions before proceeding with the work. If the Contractor performs any work that does not comply with the manufacturers' directions or such written instructions from the Architect/Engineer, he shall bear all costs arising in correcting the deficiencies.
- C. Factory Start-up by the manufacturer's Factory Certified Representative shall be provided for each Fan Coil Unit and Ionization System. Letters signed by the Representative stating that their equipment has been started, tested, and is operating safely shall be submitted to the Owner as part of the bound Operations and Maintenance Instructions manual specified in section 2.10 CATALOG DATA FOR OWNER of this specification.

## 1.7 BIDDING INSTRUCTIONS

- A. Products are generally specified by a performance specification and/or by manufacturer's name and model number or trade name.
- B. When specified only by a performance specification, the Contractor may use any manufacturer who meets the performance specification and applicable codes. (The Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS.)
- C. When several products/manufacturers are specified together, then the Contractor has the option of using any product/manufacturer listed. The Contractor shall be subject to the requirements of 1.09 - SHOP DRAWINGS. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.
- D. When several products/manufacturers are specified together and the system design is based on one of the listed products by specific model number(s) or catalog number(s), then the Contractor has the option of using the one specific product or any other product/manufacturer listed. In either case, the Contractor shall be subject to the requirements of 1.9 - SHOP DRAWINGS. However, when the other listed product/manufacturer is used, the Contractor shall be responsible for determining that the product(s) will be compatible with building design, electrical design, mechanical design, and the product(s) will not necessitate design modifications by the Architect/Engineer. The Contractor's bid shall be compiled on the use of the listed products without exception. Substitutions will only be considered after the Contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS. If the products/manufacturer are listed to be "only", then substitutions will not be considered.
- E. When only one manufacturer's name is listed, this shall be the basis of the bid. The Contractor's bid shall be compiled on the use of the listed product. Substitutions will only be considered after the Contract has been executed and shall be subject to the requirements of 1.8 - SUBSTITUTIONS.

## 1.8 SUBSTITUTIONS

- A. Substitutions will not be considered during the bid.
- B. After the Contract has been executed, the Architect/Engineer will consider a formal request for a review of substituted products in place of those specified, under the following conditions:
  - 1. Not later than 30 days from the Contract Date, the Contractor shall provide a list of products proposed as substitutions, including the name, manufacturer, and section of the specifications governing the product.
  - 2. The request shall be accompanied by accurate cost data on the proposed substitutions indicating whether or not a modification of the Contract Sum is to be considered.
- C. Substitutions are understood to mean that the installing Contractor:
  - 1. Has personally investigated the proposed substitute and has determined that it is equal or superior in all respects to the item specified;
  - 2. Will provide the same guarantee for the substitution that he would for the item or equipment specified;

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3. Certifies that the cost data is complete and includes all related costs under this Contract, and waives all claims for additional cost related to the installation of the accepted substitute;
  4. Has coordinated the installation of the substitute, providing design modifications and changes as required for the work to be complete in all respects;
  5. Has coordinated the installation of the substitute with the General Contractor pertaining to changes required for the work to be complete with all trades and all changes shall be provided without additional cost to the Owner.
- D. The acceptance by the Architect/Engineer of any or all of those substitute items listed by the Contractor for review shall not constitute an approval of the substitute but shall mean that the Contractor may then submit detailed shop drawings for review. When a request for substitution is granted, shop drawings will be reviewed by the Architect/Engineer. Shop drawings not complete with proper review information will not be reviewed and will be returned unchecked. If after two submittals, the substitute equipment is not approved, the specified equipment shall be provided.
- E. When a request for substitution is granted, shop drawings will be reviewed by the Architect/Engineer. Shop drawings not complete with proper review information will not be reviewed and will be returned unchecked. If after two submittals, the substitute equipment is not approved, the specified equipment shall be provided.

1.9 SHOP DRAWINGS

- A. Shop Drawings are required for all material and equipment that is specified by a manufacturer's name or as indicated in the technical specifications. Furnish the number of copies required by the General and Special Conditions of the Contract, but in no case less than six (6) copies. Submittal data for related equipment shall be submitted at one time.
- B. Substitutions will not be considered if:
1. They are indicated or implied on shop drawing submissions without information specified in 1.8 - SUBSTITUTIONS.
  2. They require a substantial revision of the Contract Documents in order to accommodate their use.
- C. Identify submittals with PROJECT NAME and NUMBER, CONTRACTOR'S NAME, SECTION NUMBER & NAME, and PARAGRAPH NUMBER of SPECIFICATION GOVERNING, MANUFACTURER, MODEL or STYLE, and CONTRACTOR'S REVIEW STAMP. Submittals shall be detailed, dimensioned drawings showing construction, size and arrangement, service clearances, performance characteristics, and capacity. Submittals not properly identified or containing information of a general nature will not be reviewed and will be returned unchecked.
- D. Acceptance of shop drawings shall not be considered as a guarantee of measurements or building conditions. Acceptance shall not relieve the Contractor from the responsibility or necessity of furnishing material or performing work required by the drawings and specifications. Submittal data on any one item shall not be reviewed more than three (3) times. If not accepted after the third review, the Contractor shall provide the equipment upon which the design was based.
- E. Failure to submit shop drawings in ample time for checking shall not entitle an extension of contract time, and no claim for extension by reason of such default will be allowed.

- F. No material or equipment, for which submittals are required, may be delivered to or installed at the job site until submittals have been accepted.
- G. Unless a specific finish is indicated in the contract documents, wherever a choice of finish is available for the specified item, submit accurate color chips or charts to the Architect for review and selection.

#### 1.10 COMMISSIONING

- A. Requirements common to all Heating, Ventilation, and Air Conditioning specification sections are specified in Section 01 91 13. The Contractor is referred to Section 01 91 13 for details and Contractor responsibilities relative to the commissioning process. All requirements of the commissioning process relative to the construction contract are included in specification section 01 91 13. The commissioning will be performed by the Owner's representative and is not part of the Construction Contract except as it relates to the responsibilities and information required to coordinate with the Owner's representative that is performing the commissioning.

### PART 2 - PRODUCTS

#### 2.1 DRIVE GUARDS

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings.
- B. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- C. Access for Speed Measurement: One inch diameter hole at each shaft center.
- D. Lubrication: Guards shall not interfere with lubrication of equipment.

#### 2.2 PAINTING

- A. General - Paint mechanical and electrical equipment and material in Equipment Rooms and utility type areas and located outside of the building or on the roof. Painting of equipment and material in finished rooms or areas shall be accomplished as described in PAINTING Section of the Architectural Specifications. Painting in concealed spaces shall be limited to equipment and materials not otherwise protected from rusting such as hangers and supports. Paint shall be products of Sherwin-Williams, Pittsburgh, or Pratt-Lambert. All paints, finishes and coatings shall comply with Green Seal Standard GS-11, GS-03, and SCAQMD Rule #1113 VOC limits for paints and coatings
- B. Workmanship - The work shall be accomplished by workmen skilled in the painting trade after testing is complete and systems are ready for operation. Surfaces to be painted shall be completely dry before applying paint. Surfaces shall not be painted when the temperature is below 50 Deg. F or above 120 Deg. F, or when they are exposed to hot sun. Materials shall be evenly spread and smoothly flowed on without runs or sags. Each coat shall be thoroughly dry

before application of succeeding coat. The painters shall protect adjacent surfaces with drip covers during the process of painting. Upon completion, paint spots, if any, shall be removed from adjacent surfaces.

- C. Preparation of surface - Metal surfaces shall be cleaned with solvent before applying materials. Rust and scale shall be removed by wire brushing or sanding. Galvanized surfaces shall be pretreated with a phosphoric acid cleaning solution and primed with Sherwin-Williams "Galvanized Iron Primer".
- D. Painting - After preparation as described above, each item shall be painted as follows, except color of paint for equipment and material located outside of the building or on the roof shall be as selected by the Architect.
  - 1. Painting is not required of equipment, equipment supports, and hangers with a factory-finish coat. Patch painting is required of any damaged areas to match factory-finish coat. Painting is required where equipment or equipment supports do not have factory-finish paint. Painting shall be as follows:
    - a. Uninsulated boiler surfaces and other similar hot surfaces shall be painted with two coats of silicone alkyd aluminum paint with a dry temperature resistance of 1000°F.
    - b. Other equipment and associated hangers and supports shall be primed with one coat of alkyd, zinc potassium chromate metal primer, except insulated surfaces shall be primed with one coat Sherwin-Williams "Wall Primer and Sealer." Finish with two coats of Sherwin-Williams Steel Gray Enamel. Exterior of belt guards and other protective guards shall be finished with two coats of machinery enamel in OSHA yellow color. Interior of items covered by belt guards and other protective guards shall be finished with two coats of machinery enamel in OSHA orange color. Nameplates on equipment shall not be painted.
  - 2. Ducts, pipes, and conduits - Interior duct behind grilles, registers, and diffusers shall have 1 finish coat of Sherwin-Williams Black Enamel minimum 12 inches (25 cm) back from outlet or inlet. Exposed duct, pipes, conduits, and associated hangers exposed in equipment rooms and other unfinished areas such as storage areas shall have two finish coats of paint of the same color as adjacent walls or ceilings. Bare copper pipe shall not be painted. Canvas or paper jacket insulation of pipes or duct exposed in unfinished areas shall be primed and sealed before final two coats of paint. Hangers and supports in concealed areas not protected by factory-finish paint shall have one coat of metal primer.
- E. Identification of pipes and equipment
  - 1. Equipment - Each piece of equipment shall be identified by stenciled marking that will read the same as the identification shown on mechanical or electrical drawings. Stencil letters shall be 2 inches high upper case painted with white enamel.
  - 2. Pipes shall be identified using pre-printed markers sized appropriately for the pipes being identified (shop drawings required). Markers shall be Seton "Setmark" type or equal. Pipe identification shall meet the most current edition of ANSI Specification A13.1. Markers shall be located close to valves or flanges and adjacent to changes in direction, branches and where pipes pass through walls or floors, and at intervals of 15 feet on straight runs. Provide a Color Code Chart, framed with glass front, indicating piping service and color code schedule. Post in Mechanical Room where directed by Engineer.



3. Color code schedule

COLOR BANDING CODE

<u>Number</u>	<u>Color</u>	<u>Catalog Number</u>
1.	Orange	No. F65 E 36
2.	Blue	No. F65 L 3
3.	Brown	No. F65 N 11
4.	Red	No. F65 R 1
5.	Black	No. F65 B 1
6.	Yellow	No. F65 Y 48
7.	Green	No. F65 G 40

4. Pipe shall be identified with flow arrows as described below.

- a. Arrows shall be stencil type.
- b. Arrows shall be readable from floor.
- c. Arrows shall be installed every 15'-0".
- d. Arrows shall be painted on pipes.

5. Ducts shall have flow arrows as described below.

- a. Arrow shall be stencil type, black only.
- b. Arrow shall be placed at least every 10'-0" and between duct turns over 5'-0".
- c. Arrows shall be painted on duct and shall be readable from floor.

F. Identification of Valves: Properly mark service and control valves. Valve markers shall be metal tags with designations stamped thereon or laminated engraved plastic chained to their respective valves. Identification symbols or designations shall be the same as shown on the Contract Documents.

G. Equipment locations above acoustic tile ceilings: Provide colored brass push-pins complete with a minimum 1/2" shank and 5/8" diameter head. Pin head color shall be blue or color as selected by Architect or Owner. Locate push-pins directly below all scheduled mechanical equipment.

2.3 MOTORS, CONTROL, AND ELECTRICAL WIRING

A. Provide motors in accordance with NEMA Standards and suitably designed to match the starting and running characteristics of the driven equipment. Unless indicated otherwise, motors less than 1/2 horsepower shall be wound for 120 volt, single phase, 60 hertz. Motors 1/2 horsepower and above, unless indicated otherwise, shall be wound for three phase, 60 hertz, 200 volt, 230 volt, or 460 volt as required by the system voltage. Select motors coordinated with the utilization voltage and phase. Motors for equipment with VFD shall be matched to the VFD.

B. All starters and safety switches, except for those specified to be furnished with the mechanical equipment, shall be furnished as part of the Electrical Work - Division 26.

C. Starters and safety switches furnished with the mechanical equipment shall comply with the specifications of Sections 26 28 16 and 26 29 13.13. Starters furnished as an integral part of the mechanical equipment shall be complete with properly sized overload heaters. Integral 3-phase motor starters and VFD's shall be provided with phase loss protection.

- D. Temperature control wiring shall be furnished as part of the Mechanical Work, Section 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC. Temperature control wiring is any wiring, regardless of voltage, related to mechanical equipment that is not the equipment power circuit from the circuit breaker in the panelboard to the motor starter or safety disconnect switch and to the motor or equipment junction box. Temperature control wiring shall include, regardless of voltage, power for control panels, power for actuators, signal for input and outputs, interlocks, and line voltage as herein specified to provide the proper operation and sequence of control for all heating, ventilating, and air conditioning equipment. All wiring shall conform to applicable sections of Division 26, 27 and 28 of the specifications.
1. Power for control panels shall be provided by Controls Contractor and shall be obtained from nearest receptacle or unswitched 120 volt lighting circuit. Control Contractor shall coordinate with Electrical Contractor when connecting to these circuits. Circuit directories in panelboards shall indicate where control panels are connected. When control panels require voltage other than 120 VAC, Control Contractor shall provide transformer to reduce voltage. All wiring shall conform to applicable sections of Division 26, 27 and 28 of the specifications.
  2. Power for damper actuators and valves which are an integral part of mechanical equipment shall be provided by the Controls Contractor and shall be obtained from the power source to the equipment or the nearest receptacle circuit. Where power requirement for the actuator or valve is different from that supplied to the equipment, the Controls Contractor shall provide a transformer or tap the nearest receptacle circuit or unswitched 120 volt lighting circuit. Dampers located at fans shall be considered an integral part of the mechanical equipment and shall be factory wired to the equipment power source.
  3. Where equipment is controlled by a line voltage control device (thermostat, On-Off switch, Speed Switch, etc.) the Controls Contractor shall wire from the control device to the equipment, unless specifically indicated otherwise on the drawings.
  4. Where control devices that are intended to interrupt the motor or equipment power circuit are provided by the Control System Contractor and are mounted other than on or directly adjacent to the controlled equipment, the Control System Contractor shall provide wiring through these devices regardless of voltage or phases.
  5. All low voltage control wiring in inaccessible areas or in exposed areas shall be in metal conduit and shall comply with the specifications of Divisions 26, 27 and 28. All low voltage control wiring in unexposed, accessible areas shall be wire in conduit or U.L. approved plenum rated cable supported from the structure with ties spaced 4'-0" on center. Cable shall not be supported on ceiling, lights, or pipes. All low voltage control wiring penetrating walls or floors shall be in conduits. All 120 volt wiring shall be wire in conduit and shall comply with the specifications of Division 26, 27 and 28. All wall-mounted thermostats, sensors, and switches shall be mounted in recessed metal rough-in box.
  6. The Controls Contractor shall coordinate with the Electrical Contractor all 120 volt power source, connections required for the controls system. The Controls Contractor shall verify that wiring of motors and controls provides the correct sequence of operation.
  7. All equipment that has electrical connections shall have wiring terminals/connectors rated for not less than 75 deg. C. If terminals/connectors are provided and are rated for less than 75 deg. C., the mechanical contractor shall incur all costs associated with upsizing wire and conduit as required by the National Electrical Code.

## 2.4 FIRE-STOPPING

- A. Pipe penetrations of rated walls, floors, and floor-ceiling assemblies shall be constructed in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Hourly Ratings for Through Firestop Penetrations. The Contractor shall provide U.L. firestop penetrations according to the particular wall, floor, or floor-ceiling assembly rating, construction type, pipe material, pipe size, insulation requirements, sleeve requirements, and the contractor's choice of firestop products as listed by U.L. Refer to the architectural drawings for the wall, floor, or floor-ceiling assembly construction types and ratings.

## 2.5 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall furnish and install all accessories, connections, bases, guards, supports, and incidental items necessary to fully complete the work, ready for use, occupancy, and operation by the Owner.
- B. Type Numbers Specified: MSS SP-58; for selection and application, MSS SP-69. Refer to Section METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.
- C. For Attachment to Concrete Construction
  - 1. Concrete Insert: MSS SP-69, Type 18
  - 2. Self-Drilling Expansion Shields and Machine Bolt Expansion Anchors: Fed. Spec. FF-S-325, permitted in concrete not less than four inches thick. Applied load shall not exceed one-fourth the proof test load listed in Fed. Spec. FF-S-235.
  - 3. Power-Driven Fasteners: Permitted in existing concrete or masonry not less than four inches thick when approved by the Architect/ Engineer for each job condition. Use fasteners capable of supporting a 1000 pound test load, with the actual load not exceeding 50 pounds.
- D. For Attachment to Steel Construction; MSS SP-69:
  - 1. Welded Attachment: Type 22.
  - 2. Beam Clamps: Types 20, 21, 23, 28 or 29.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Section METAL DECKING.
- F. For Attachment to Wood Construction: Wood screws or lag bolts.
- G. Hanger Rods: Hot-rolled steel, ASTM A 36 or A 575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turnbuckles shall provide 1-1/2 inches minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-1/2 inches by 1-1/2 inches, No. 12 gage, designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping, fire and sprinkler piping, or chemical waste drain piping.
  - 1. Allowable Hanger Load: Manufacturers rating less 200 pounds.

2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4-inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 2-inch galvanized steel bands, for insulated piping at each hanger.
- I. Pipe Hangers and Supports: Use hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 00, HVAC INSULATION, for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports. Provide Type 40 insulation shields at all other types of supports and hangers including those for pre-insulated piping.
1. General Types (MSS SP-69):
    - a. Standard Clevis Hanger: Type 1; provide locknut.
    - b. Riser Clamps: Type 8 or 42.
    - c. Wall Brackets: Types 31, 32, or 33.
    - d. Roller Supports: Type 41, 43 and 46.
    - e. Saddle Support: Type 36, 37, or 38.
    - f. Turnbuckle: Types 13 or 15.
    - g. U-Bolt Clamp: Type 24.
    - h. For Uninsulated Copper Tube: Material compatible for use with copper to prevent electrolysis.
    - i. Supports for Plastic or Glass Piping: As recommended by the pipe manufacturer.
  2. HVAC Piping:
    - a. Low, Medium and High Pressure Steam:
      - (1) Provide eye rod or Type 17 eye nut near the upper attachment.
      - (2) Piping 3 Inches and Larger: Type 43 roller hanger. For roller hangers requiring seismic bracing, provide a Type 1 clevis hanger with Type 41 roller attached by flat side bars.
    - b. Spring Supports (Expansion and Contraction of Vertical Piping):
      - (1) Movement up to 3/4-Inch: Type 51 or 52 variable spring unit with integral turnbuckle and load indicator.
      - (2) Movement more than 3/4-Inch: Type 54 or 55 constant support unit with integral adjusting nut, turnbuckle, and travel position indicator.
  3. Plumbing Piping:
    - a. Sprinkler System: NFPA or Factory Mutual approved types.
    - b. Horizontal Piping: Types 1, 5, 7, 9, and 10.
    - c. Chrome Plated Piping: Chrome plated supports.
    - d. Hangers and Supports in Pipe Chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration, and compensate for all static and operational conditions.
    - e. Blocking, Stays and Bracing: Angle iron or preformed metal channel shapes, 18 gage minimum.
- J. Support hubless cast iron pipe and fittings per CISPI 301-12. Brace hubless cast iron pipe and fittings 5 inches and larger using Holdrite 117 Series No-Hub Pipe and Fitting Restraints or approved equal.

## 2.6 PIPE SLEEVES

- A. Locate sleeves during normal course of work. Provide sleeves for piping and conduit passing through concrete floor slabs and concrete, masonry, tile, and gypsum wall construction. Sleeves shall not be provided for piping and conduit running embedded in concrete or slab on grade, except that copper piping shall require sleeves through slabs on grade. Sleeves through structural members shall be only as directed by Architect. In interior wall, provide 1/4 inch space all around between sleeve and conduit, piping, or insulation of piping.
- B. Sleeves placed in exterior walls below grade shall be O.Z. Gedney Type 'FSK' or equal, Thunderline 'LINK SEAL', or equal sleeve assemblies sized for the pipe or conduit encountered, except for cast iron piping. Sleeve assembly shall provide watertight seal and electrical insulation to reduce cathodic reaction. When a sleeve passes through a wall below a concrete slab on grade, the sealing assembly shall be on the outside of the wall. When a sleeve passes through a wall into a crawl space or the building interior, the sealing assembly shall be in the crawl space or interior of the building. Provide sleeve assembly for copper piping through slab on grade, with sealing assembly located on interior side of floor slab. Where cast iron pipes pass through an exterior wall below grade, provide an iron-pipe sleeve two (2) pipe sizes greater than pipe passing through. Caulk between pipe and sleeve with a rubber-based compound.
- C. Where sleeves are located through fire-rated walls and floor/ceiling assemblies, provide sleeves and protect the penetration in accordance with Underwriter's Laboratories, Inc., Fire Resistance Directory, Volume II, Ratings for Through Firestop Penetrations.
- D. Sleeves in mechanical rooms with floor drains or hose bibbs shall extend 4 inches above floor. Provide flanges or flashing rings with sleeves in floors with waterproof membrane and clamp or flash into the membrane. Provide sleeves flush with floor in other rooms.
- E. Sleeves shall be constructed of 20 gage galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated.
- F. Fasten sleeves securely in floors or walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster, or other materials from being forced into the space between pipe and sleeve during construction.

## 2.7 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS)

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with setscrew for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes, and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 3/32-inch for floor plates. For wall and ceiling plates, not less than 0.025 for up to 3-inch pipe, 0.035 for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, except mechanical rooms.

## 2.8 ACCESS PANELS

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- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall provide access panels in all locations where required for access to concealed valves, traps, air cushions, controls, dampers, damper operators, junction boxes, and any other equipment or materials requiring inspection or maintenance. Access panels shall be of adequate size and properly located so that concealed items will be readily accessible for servicing or for removing and replacing if necessary, except as indicated or specified otherwise. Access panels are not required in ceilings formed of removable acoustical panels.
- B. Access panels that are not fire-rated shall be Milcor or equal. Provide modular-sized access panels in inaccessible acoustic tile ceilings sized according to the tile size. Provide Milcor metal access panels with cam lock and mounting trim to match finish encountered. Provide natural anodized aluminum finish for panels in kitchens and toilets. Provide prime finished steel for panels in other areas. Paint panels in finished areas to match finish surface.
- C. Where indicated and where access panels are installed in walls of shafts that are not sealed at each floor, access panels shall be Milcor or equal "Fire-Rated" and shall bear the Underwriters' Laboratories, Inc. Class B, 1-1/2 hour label. Openings shall be framed in accordance with the access panel manufacturer's recommendations. Frames shall be not lighter than 16-gage steel. Panels shall be not lighter than 20-gage steel and shall be insulated sandwich type. Panels shall have a continuous hinge, self-lubricating lock, a direct action-knurled knob, and an interior latch release mechanism.

### 2.9 CHARTS, DIAGRAMS, AND SCHEMES

- A. Charts, diagrams, and schemes listed below shall be provided under each applicable section of the detailed mechanical specifications by the Contractor, framed under glass, and installed where shown on the drawings or directed in the field. All charts, diagrams, and schemes shall be complete, neat, clear, legible, and permanent.
- B. Electric sequence control diagrams of all mechanical system components.
- C. Automatic temperature control diagrams identified as to name, sequence of operation, location, function, temperature setting, spring range, and manufacturer's part number.
- D. Valve identification chart with typewritten schedule of all valves giving their tag number, description, system served, and normal operation position.
- E. Piping schemes where required by the detailed specifications.

### 2.10 CATALOG DATA FOR OWNER

- A. Furnish one (1) bound copy of Catalog Data on each manufactured item of equipment used in the mechanical work, complete with index listing the products alphabetically by name, together with the names and addresses of manufacturers, sales, and service representatives. Furnish two (2) bound copies of Operating and Maintenance Instructions of each item of equipment. Catalog Data and Operating and Maintenance Instructions shall be submitted to the Engineer for review prior to transmittal to the Owner.

### 2.11 RECORD OF AS-BUILTS AND CONDITIONS

- A. Provide a complete set of prints of mechanical plans marked to indicate as-built conditions which are different from those shown on the original construction documents. Site as-built conditions which are different from the construction documents shall be dimensioned from building or identifiable marker. Accurate locations of all concealed utility lines, both interior and exterior shall be recorded. These drawings shall be delivered to the Architect/Engineer before being turned over to the Owner.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

#### A. Coordination of Work:

1. The Contractor shall compare the mechanical drawings and specifications with the drawings and specifications of other trades, and shall report any discrepancies between them to the Architect/Engineer, and shall obtain from him written instructions for changes necessary in the mechanical work. The mechanical work shall be installed in cooperation with other trades installing interrelated work. Before installation, the Contractor shall make proper provision to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor caused by his neglect to do so shall be made by him at his own expense.
2. Anchor bolts, sleeves, inserts, and supports that may be required for the work shall be fully coordinated and compatible with the related equipment or materials. Locations shall be determined by the trade installing the related equipment or materials.
3. Slots, chases, openings, and recesses through floors, walls, ceilings, roofs, and partitions shall be located by the trades requiring them.
4. Locations of pipes, ducts, equipment, fixtures, etc., shall be adjusted to accommodate the work to interferences anticipated and encountered. The installing Contractors shall coordinate their work to the building structure and to other trades as directed by the General Contractor. No additional compensation or extension of completion time will be granted for extra work caused by a lack of coordination. The installing Contractor shall provide dimensions and locations of all openings, shafts, and similar items to the General Contractor for his coordination and execution. Work shall be installed as required so as not to interfere with or delay the building construction. Pipes, ducts, etc., shall be concealed above ceilings, in walls, or in floors as applicable in all areas of the building except in equipment rooms, unfinished storage rooms, or other areas specifically noted to the contrary.
  - a. Right-of-Way: Lines which pitch shall have right-of-way over those which do not pitch. For example, plumbing drains shall normally have right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.
  - b. Offsets, transitions, and changes in direction of pipes and ducts shall be made as required to maintain proper head room and pitch of sloping lines whether or not indicated on the drawings. The Contractor shall furnish and install all traps, drains, air vents, sanitary vents, etc., as required to affect these offsets, transitions, and changes in direction.
5. Exact locations of items such as diffusers, grilles, thermostats, hose bibbs, wall hydrants, and other similar items in finished areas of the building and on the exterior of the building

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shall be coordinated with each other, the building structure, and architectural features thereof so as to be aligned with or centered on other items as applicable. Locations indicated on the drawings are approximate. Trades shall coordinate their work with door swings, block coursing, tile arrangement, and other similar features before establishing the location of any components. Before any related work has begun, the Architect/Engineer may direct reasonable minor changes in equipment locations with no increase in contract price to the Owner. Thermostats shall be mounted so that the top of the thermostat is 48" above the floor and aligned with the top of the light switch plates and 8" from the light switch if shown on the drawings adjacent to a light switch. Room thermostat locations shall be coordinated with door swings, light switches and other wall mounted items. Corridor thermostats shall be mounted 60" above finished floor. Before roughing in conduit or pipe, verify the location of equipment to be connected.

6. Installation and Arrangement: The Contractor shall install all mechanical work to permit removal of coils, heat exchanger bundles, boiler tubes, fan shafts and wheels, filters, belt guards, sheaves and drives, and all other parts requiring periodic replacement or maintenance. The Contractor shall arrange pipes, ducts, and equipment to permit ready access to valves, cocks, traps, motors, control components, and to clear the openings of swinging and overhead doors and of access panels.
7. Ductwork: The Contractor shall change the cross-sectional dimensions of ductwork when required to meet job conditions but shall maintain at least the same equivalent cross-sectional area. The Contractor shall secure the approval of the Architect/Engineer prior to fabrication of ductwork requiring substantial changes. Ductwork shall not be fabricated until coordination with available space.
8. Drawings by Contractor: When directed by the Architect/Engineer, the Contractor shall submit for review by Architect/Engineer drawings clearly showing certain portions of the mechanical work and its relation to the work of other trades before beginning shop fabrication or erection in the field.
9. Dimensions: The Contractor shall ensure that items to be furnished fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connections, and shall furnish and install such sizes and shapes of equipment that the final installation shall suite the true intent and meaning of the drawings and specifications. If he concludes that there is insufficient space for installation or specified materials, he shall immediately notify the Architect/Engineer of the conflict and shall stop affected work until he receives instructions as to how to proceed from the Architect/Engineer.
10. Damage to Work: The Contractor is responsible for damage caused by his work or workmen. Repairing of damaged work shall be done by the Contractor as directed by the Engineer at no additional cost.
11. The Contractor shall be responsible for any interruptions to existing services and shall repair any damages to existing systems caused by his operations.

### B. Protection and Cleaning:

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items, in the opinion of the Architect/Engineer, shall be replaced.
2. All items subject to moisture damage (such as controls and electrical equipment) shall be stored in dry, heated spaces.
3. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water, chemical or mechanical injury. Clean mechanical



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equipment to remove dust, oil, dirt, plaster, mortar, trash, or paint. Piping, conduit, and ductwork shall be blown out or flushed of all foreign matter before wires are pulled in or before connections are made to equipment or systems. (Clean each boiler in accordance with manufacturer's instructions before connecting to the system.) Provide temporary filters for air units that are operated during construction. After all construction dirt has been removed from the building, install new filters in air units.

- C. Concrete and Grout: Use concrete and shrink compensating grout 3000 psi minimum.
- D. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- E. Work in Existing Buildings:
  - 1. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills will be permitted only with approval of the Architect/Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Architect/Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Architect/Engineer's approval, carefully cut opening through construction not larger than is absolutely necessary for the required installation.
  - 2. Remove existing work as necessary to install new work. Except as otherwise shown or specified, do not cut, alter or remove any structural work or any ducts, plumbing, steam, gas or electric work without approval of Architect/Engineer. Existing work (walls, ceilings, partitions, floors, mechanical, and electrical work) disturbed or removed as a result of performing required new work shall be patched, repaired, reinstalled, replaced with new work, and refinished and left in as good condition as existed before commencing work. Existing work to be altered or extended that is found to be defective in any way shall be reported to the Architect/Engineer before it is disturbed. Materials and workmanship used in restoring work shall conform in type and quality to that of original existing construction, except as otherwise shown or specified.
  - 3. Continuity of service shall be maintained to all existing systems, except for designated short intervals during which connections are to be made. Interruptions shall be coordinated with the Owner as to the time and duration.
  - 4. Upon completion of contract, deliver work complete and undamaged. Damage that is caused by Contractor or Contractor's workmen to existing structures, grounds, or utilities or to work done by others shall be repaired by Contractor and left in as good condition as existed prior to damaging.
    - a. At Contractor's own expense, Contractor shall immediately restore to service and repair any damage caused by Contractor's workmen to existing piping and conduits, wires, cable, etc., of utility services or of fire protection system and communications systems (except telephone) which are not scheduled for discontinuance or abandonment.
    - b. Restoration work required by damage to telephone systems shall be done by telephone company at Contractor's expense.

### 3.2 PIPING

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- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall furnish and install as shown on the drawings or as necessary to complete the working system in accordance with the intent of the drawings and specifications, a complete system of piping, valves, supports, anchors, sleeves, and all other appurtenances. The piping drawings are diagrammatic and indicate the general location and connections. The piping may have to be offset, lowered, or raised as required or as directed at the site. This does not relieve the Contractor of responsibility for the proper erection of systems of piping in every respect suitable for the work intended as described in the specifications and as approved by the Architect/Engineer. Wherever two dissimilar metals join in any piping system, install a dielectric fitting at their intersection.
- B. Installation: Piping shall be properly supported and adequate provisions shall be made for expansion, contraction, slope, and anchorage without damage to joints or hangers. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe extending through the roof shall be properly flashed. All changes in direction shall be made with fittings. Wherever pipe hanger bears directly on the pipe being supported, the hanger shall be of the same material as the pipe.
- C. Arrangement: All piping shall be arranged so as not to interfere with removal of other equipment or devices nor to block access to doors, windows, manholes, or other access openings. Piping shall be arranged so as to facilitate removal of tube bundles. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment. Piping shall be placed and installed so that there will be no interference with the installation of the equipment, ducts, etc. All piping shall be installed to ensure noiseless circulation. All piping shall be erected and pitched to ensure proper drainage. Piping shall be installed so as to avoid liquid or air pockets throughout the work. Pipe in finished areas shall be concealed. Exposed piping shall be installed in practical alignment with the building. All valves and specialties shall be placed to permit easy operation and access, and all valves shall be regulated, packed, and glands adjusted at the completion of the work before final acceptance. Water pipes shall not be installed in attic spaces, crawl spaces or similar areas which are subject to freezing, unless indicated to be heat traced.
- D. Underground Piping: Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with adjoining pipe and to prevent sudden offsets to flow line. As work progresses, the interior of the pipe shall be cleared of dirt and superfluous materials of every description. Where cleaning after laying is difficult because of small pipe size, a suitable swag or drag shall be kept in the pipe and pulled forward past each joint immediately after jointing has been completed. Trenches shall be kept free from water until pipe jointing material has set. Pipe shall not be laid when the condition of the trench or weather is unsuitable for such work. At all times when work is not in progress, all open ends of pipe and fittings shall be securely closed so that no water, earth, or other substance will enter the pipe or fittings.

### 3.3 PIPE AND EQUIPMENT SUPPORTS

- A. Supports: The Contractor shall support plumb, rigid, and true to line all work and equipment furnished under each section of these specifications. The Contractor shall study thoroughly all general, structural, and mechanical drawings, shop drawings, and catalog data to determine how equipment, fixtures, piping, ductwork, etc., are to be supported, mounted, or suspended, and shall provide extra steel bolts, inserts, pipe stands, brackets and accessories for proper support, whether or not shown on the drawings. When directed, the Contractor shall submit drawings showing supports for review by the Architect/Engineer.
- B. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Architect/Engineer.
- C. Use of chain, wire or strap hangers; wood for blocking stays or bracing; or hangers suspended from piping above will not be permitted. If products are rusty, replace or thoroughly clean and coat with prime paint.
- D. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 2-inch clearance between pipe or pipe covering and adjacent work.
- E. Horizontal Pipe Support Spacing:
  - 1. Cast Iron: Five feet on centers maximum spacing. At least one hanger on each full length of pipe, close to hub where possible and at least one within 24 inches of each fitting, and wherever else required to prevent tendency toward deflection due to load. Provide a hanger at upper angle at each drop. Locate hangers adjacent to hubs on multiple fittings not more than four feet on centers.
  - 2. For support spacing of all other horizontal piping, refer to MSS SP-69 and provide additional supports at valves, strainers, inline pumps and other heavy components. Provide a support within one foot of each elbow.
  - 3. Black Steel Gas Piping: 8 feet on centers maximum spacing for on-roof horizontal supports. Provide a support within one (1) foot of each elbow.
- F. Vertical Pipe Supports – HVAC and Gas:
  - 1. Vertical runs less than 15 feet long may be supported by the hangers on the connecting horizontal runs.
  - 2. Up to 6-Inch Pipe, 60 Feet Long or Not Over 12-Inch Pipe Up to 30 Feet Long: Riser clamps bolted to pipe below couplings, or welded to pipe and resting securely on the building structure.
  - 3. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- G. Connections: All piping connecting to equipment shall be installed without strain at the piping connection. The Contractor shall be required as directed to remove the bolts in flanged connections or to disconnect piping to demonstrate that piping has been so connected.

- H. Gas Piping Supports: Shall have electro-galvanized steel top with (aluminum roller) (polymeric) supports, the roller axle, fittings and other hardware shall be galvanized steel or polymeric material. Support base shall be secured to roof with adhesive roofing mastic. Roofing membrane shall be compatible with mastic. Consult manufacturer of existing roofing system if isolation pads are required between roof membrane and support base. Consult manufacturer of existing or new roofing system to verify appropriate adhesive to bond base to roofing surface. Do not use wood as support materials. (Support base shall be secured to roof with zinc-coated bolts to structure.)
- I. Gas Piping Anchors: Shall be bolted or field welded to piping. Anchors shall be attached with zinc-coated or galvanized bolts or field welded to angle iron attached to building structure and HVAC equipment curb.

### 3.4 MOTOR AND DRIVE ALIGNMENT

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-Connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

### 3.7 CUTTING AND PATCHING

- A. The Contractor shall be responsible for all required digging, cutting, etc., incident to the work, and shall thereafter make all required repairs necessary to restore the cut structure or material to the condition existing prior to the cutting. In no case shall the Contractor cut into any major structural element, beam, or column without the written approval of the Architect/Engineer. All cutting, patching, repairing, or replacing of work required because of fault, error, tardiness, or damage by any trade shall be performed with no increase in the contract price to the Owner.
- B. Patch and repair roof in accordance with requirements of existing roof warranties and manufacturer's standard approved details.

### 3.8 LUBRICATION

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall provide all oil and grease required for the operation of all equipment until acceptance by the Owner. The type and application of all lubricants shall conform to the recommendations of the manufacturer of the equipment involved. The Contractor shall be held responsible for all damage to bearings while the equipment is being operated by him up to the date of acceptance of the project. This Contractor shall be required to protect all bearings during installation and shall thoroughly grease or otherwise protect steel shafts and other bare ferrous parts to prevent corrosion. All equipment shall be provided with covers as necessary for proper protection against damage or deterioration during construction.

### 3.9 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC, and submit the test reports and records to the Architect/Engineer.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Owner.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of the work.

### 3.10 QUIET OPERATION AND VIBRATION

- A. Systems shall operate under conditions of load without unusual or excessive noise or vibration. Unusual or excessive noise or vibration shall be corrected.

### 3.11 INSTRUCTIONS TO OWNER'S PERSONNEL

- A. Under each applicable section of the detailed mechanical specifications, the Contractor shall instruct the representative of the Owner in the proper operation and maintenance of all elements of the mechanical systems. A competent representative of the Contractor shall spend not less than two days in such formal instruction and shall spend such additional time as directed by the Architect/Engineer to fully prepare the Owner to operate and maintain the mechanical systems. The Contractor shall provide letter of instruction upon completion to the Architect/Engineer stating the date of instruction and the names of those in attendance.

### 3.12 GUARANTEE

- A. All mechanical equipment, materials, and labor required by the contract documents for this project shall be guaranteed to be free of defective materials or workmanship for a period of one year after final acceptance of the project. Defects in equipment, materials, or workmanship occurring during this period shall be corrected with new equipment and materials or additional labor at no cost to the Owner.

### 3.13 SITE VISIT REPORT

- A. Answer in writing each item of discrepancy noted on all site visit reports.

### 3.12 DEMOLITION

- A. Contractor shall visit the site before bidding to determine the extent and location of demolition to be performed.

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- B. Contractor to remove all pipes, ducts, equipment, controls, etc. not required, reused or needed for reconnecting to the new systems. All items not required for the new system shall be removed.
- C. The Owner shall select and retain such existing items indicated or required to be removed as he desires. Items selected by the Owner to be retained shall be removed and relocated to an Owner designated location by the Contractor.
- D. All equipment, piping, ductwork, conduit, etc. to remain and be reused shall be protected from damage. Any damage to existing material shall be repaired to original condition.
- E. Coordinate all demolition activities with the phasing of construction. Demolition shall not affect operations of the building.

3.13 PHASING OF WORK

- A. The mechanical contractor is required to fully understand the phasing of work and to coordinate his work according to phasing plan drawings and related sections of the specifications.
- B. Sections of the existing building will continue to be occupied during renovation. The contractor shall be responsible for retaining existing HVAC systems to serve the occupied sections of the building. Otherwise, the contractor shall provide interim HVAC systems for the occupied sections of the building.
- C. The contractor is cautioned to fully understand the need to operate HVAC systems during construction and to block off ductwork serving areas under construction. Protect return ductwork with temporary filters at air inlet grilles, etc.
- D. Provide temporary HVAC to protect the owner's property from freeze damage and from high humidity. For new construction, provide HVAC for proper drying and application of finishes.
- E. Portions of the renovated building will be reoccupied as sections of renovation become complete. The contractor shall be responsible for providing HVAC for the reoccupied sections of building.

END OF SECTION 230000

## SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC

### PART 1 - GENERAL

#### 1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

#### 1.2 DESCRIPTION OF WORK

- A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems.
- B. The Contractor shall provide all labor, materials, instruments, equipment and service and shall perform all operations required for testing, adjusting, and balancing of systems and related work to obtain the performance of the systems as shown on the drawings and in the specifications.
- C. Definitions:
  - 1. Basic TAB terms used in this section: "Testing, Adjusting and Balancing" of ASHRAE Handbook, latest edition.
  - 2. TAB: Testing, adjusting and balancing. The process of checking and adjusting HVAC systems to meet design objectives.
  - 3. AABA: Associated Air Balance Council.
  - 4. NEBB: National Environmental Balancing Bureau.
  - 5. Hydronic Systems: Includes heating water and chilled water (HVAC).
  - 6. Air Systems: Includes all supply air, return air, exhaust air and outside air systems.

#### 1.3 RELATED WORK

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230900, INSTRUMENTATION AND CONTROLS FOR HVAC.
- C. Section 232000, HVAC PIPING AND PUMPS.
- D. Section 232133, VARIABLE SPEED DRIVES.
- E. Section 233000, HVAC AIR DISTRIBUTION.
- F. Section 238200, CONVECTION HEATING AND COOLING UNITS.

#### 1.4 QUALITY ASSURANCE

- A. TAB Agency Qualifications: The Contractor shall provide the services of a firm certified by the Associated Air Balancing Council, or the National Environment Balancing Bureau to adjust and balance all heating, ventilating, air conditioning, and exhaust systems. All personnel involved in the execution of the work shall be experienced in the balancing of mechanical systems. The firm shall not be the installer of the systems to be tested and shall be otherwise independent of the project.
- B. Performance Criteria: Work shall be performed in accordance with the approved TAB Agenda.
- C. Test Equipment Criteria: The basic instrumentation requirements and accuracy/calibration required by AABC (Section Two) or Section II of the NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
- D. Guarantee: The AABC or NEBB certified firm shall guarantee that all testing, adjusting and balancing work shall be performed in accordance with NEBB standards and procedures and shall provide evidence of their certification for the Architect/Engineer.

#### 1.5 THE TAB AGENDA

- A. Definition: The proposed TAB procedures and proposed forms, diagrams, and reports for documenting the TAB work.
- B. Preparation: By the TAB Agency for review and approval by the Architect/ Engineer.
- C. The agenda shall include one complete set of the AABC or NEBB publications or, in the case of other TAB organizations, comparable publications to establish an approved systematic and uniform set of procedures.
- D. The Agenda shall also include the following detailed narrative procedures, system diagrams and forms for test results.
  - 1. Specific standard procedures required and proposed for each system. Additional procedures for variable flow systems shall be developed by the TAB Agency and included for review and approval.
  - 2. Specified test forms for recording each TAB procedure and for recording sound and vibration measurements. Additional test forms for any variable flow systems shall be developed by TAB agency and submitted for review and approval.
  - 3. System diagrams for each air and water system. Diagrams may be single line. In addition to the information recorded for standard AABC or NEBB procedures, report the following information:
    - a. Air Handling Units: Show design and actual CFM (outside air, return air, supply air). Measure and record each mode (minimum OA and 100% OA) where economizer cycle is specified.
    - b. Duct Distribution Systems: Record residual pressures at inlets of volume controlled terminals at ends of system. Show actual pressures at all static pressure control points utilized for constant or variable flow systems.



- c. Variable Flow Systems (Water): Include in test forms provisions for measuring and reporting GPM (primary, secondary), system pressures, motor loads, other pertinent data, at full unthrottled capacity and at design (100 percent) flows. Modulate systems by varying the supply temperature of the medium or other approved means.
- d. Water Systems: Record system fill pressures and expansion tank (level, pressure, temperature) conditions. Record shut-off heads for all pumps and compare with pumps curves to determine if correct pump impellers have been installed.

## 1.6 SUBMITTALS

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, furnish the following:
  - 1. TAB Agency qualifications, submit name and qualifications of job supervisor.
  - 2. Upon approval of TAB Agency, submit TAB AGENDA for approval.
  - 3. After completion of tests, the Contractor shall submit three copies of complete test reports for approval. Applicable NEBB or AABC reporting forms shall be used. Where test results differ from specified design conditions, indicating a contract deficiency, include explanatory comments in report. The Contractor shall submit final reports prior to requesting the final inspection for the project.
  - 4. Approved copy of report shall be bound in Operations and Maintenance Manuals; see Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements.

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. The TAB agency shall be responsible for all items or materials necessary for connection of its instrumentation to the ductwork, piping or equipment. Test ports in ducts and plenums shall be installed by the Mechanical Contractor as directed by the TAB agency during the construction of the systems. Test ports shall be identified. Do not proceed with testing, adjusting, and balancing work until systems are complete and operational.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. The General Contractor shall furnish a complete set of HVAC drawings and specifications to the TAB agency. The agency shall review plans and specifications prior to systems installation and submit a written report indicating deficiencies in the system that would preclude the proper adjusting, balancing, and testing of the system. The HVAC system shall be complete and fully operational with clean air filters and clean pipe strainers prior to system balancing. The TAB agency shall review the installed system for proper installation of testing, adjusting, and balancing equipment and submit a written report indicating system conditions. The Mechanical Contractor shall provide support through factory representatives, equipment mechanics, and

control technicians to work with the balancing organization to adjust equipment and controls to obtain design performance.

- B. Coordinate TAB procedures with any phased construction requirements for the project so that usable increments of finished work may be accepted for beneficial occupancy. Systems serving partially occupied phases of the project may require balancing for each phase prior to final balancing.
- C. Allow sufficient time in construction schedule for TAB prior to final inspection for the project.
- D. Accomplish TAB in accordance with the Agenda approved by the Architect/Engineer. Put all HVAC systems into full operation and continue operation of the systems during each working day of TAB.
- E. Notify Architect/Engineer 48 hours prior to TAB work.
- F. The TAB agency shall be responsible for adjusting sheaves to acquire required air quantities. If the sheaves require replacement, the sheaves and belts will be replaced by the installer of the equipment.
- G. One week before the final site visit, the balancing organization shall provide the Architect/Engineer with three (3) typed copies of balance reports, in format recommended by NEBB. The report shall contain the following:
  - 1. Project name, location, contractors names, balancing organizations' name, and date.
  - 2. Balancing organizations' certification and individual certified qualifications of persons responsible for supervising and performing the actual work.
  - 3. Brief description of balancing instruments used for this project and their latest calibration performance.
  - 4. Weather conditions at the beginning and end of each day to include; outside dry bulb and wet bulb temperatures, general weather description and cloud cover.
  - 5. System data for each unit:
    - a. Installation data as applicable; mark, location, manufacturer, model, size, arrangement, motor HP, voltage, phase, and full load amps.
    - b. Design quantities and balance readings taken during the balancing operation indicating the quantity measured on the first reading, and the final, balanced, measured quantity for air and hydronic balance.

### 3.2 AIR BALANCE

- A. Place all interactive systems in operation with all filters installed and automatic control systems completed and operating. Artificially load air filters by partial blanking or other means to produce air pressure drop midway between the clean and dirty condition. Set/reset room thermostats as necessary to check heating and cooling function, and flow rates for factory set air terminal units and adjust units if not correct.
- B. Balance systems to design ratings. Adjust fan speeds to provide design flows, including system diversities, at actual system pressures. V-belt drives, including fixed pitch requirements, are specified in Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements. Coordinate VAV balancing, including supply and return fan volume controls, with Section 23 09 00, Instrumentation and Controls for HVAC. Set supply fan static

pressure control as low as practicable and still maintain required pressure at the remote terminal units. The drive motor of each fan shall not be loaded over the corrected full load amperage rating of the motor involved.

- C. Make pitot tube traverses of all trunk lines and major branches when required to determine proper proportioning of air flows. Air flow measuring devices, where installed, may be utilized for this purpose.
- D. Record pressure drop readings across all major systems.
- E. Make flow measurements at each terminal device and each supply, return, or exhaust diffuser. Adjust each air outlet unit within plus or minus 10 percent of design requirements. Adjust grilles and diffusers to minimize drafts in all areas.
- F. Adjust outside air and return air quantities for all systems to within plus or minus 10 percent.
- G. Adjust exhaust systems to CFM requirements. After balance is completed, change variable shims to fixed shims.
- H. Test function of automatic dampers and operation of air terminal units.
- I. Any adjustments necessary to achieve the specified results shall be provided by the Contractor who furnished and installed such equipment under his contractual obligations. Such adjustments may encompass, but are not necessarily restricted to, the changing of pulleys and belts.
- J. Report the air balance readings for the following as further specified in 3.01.G:
  - 1. Air handling equipment - Outdoor air quantity, return air quantity, supply air quantity, fan speed (rpm), static pressure at fan suction and discharge (inches wg.), and actual motor amp and voltage reading.
  - 2. Exhaust fans - Air quantity, fan speed (rpm) and static pressure, actual motor amps and voltage reading.
  - 3. Each air distribution outlet and inlet identified by location and size, air velocity (fpm) and computed air quantity (cfm).
  - 4. Water coils - Air flow (cfm), entering and leaving air temperatures (DB and WB), load (BTU or MBH).
  - 5. Temperature in each room in building and thermostat setting.

### 3.3 HYDRONIC BALANCE

- A. Perform final hydronic balance after all systems have been flushed, cleaned, and filled.
- B. Hydronic balance includes performance readings on all pumps, coils, heat exchangers, and flow measuring devices. Adjust pump flows to actual system heads by adjustment of balancing valves. Flow measuring devices take precedence over pump head readings. Record discrepancies for evaluation. The drive motors shall not be loaded over the corrected full load amperage rating of the motor involved.
- C. Report pressure drop readings across all major system components both for flow determination and deviations between actual and design values.

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- D. Record on flow diagrams the flows obtained in each of the various circuits and modes of operation. Designate the manual rebalancing effort that is necessary for optimum operations. Measure flows in primary and secondary pumping systems when operating independently and jointly. Measure and record flows and power consumption of variable flow systems at maximum flow conditions and in increments of 10 percent reductions to a minimum system condition.
- E. Report the hydronic balance readings for the following as further specified in 3.01.G:
  - 1. Water coils - Water flow (gpm), entering and leaving water temperatures.
  - 2. Converters - Water flow (gpm), steam valve position, steam pressure, entering and leaving water temperature, load (MBH).
  - 3. Pumps - Water flow (gpm), suction and discharge pressures, operating head, and full load amps.

**3.4 TEMPERATURE CONTROL TEST**

- A. After the heating, ventilating and air conditioning systems have been adjusted and balanced completely, a six hour test shall be run on both the heating and cooling cycles, including the economizer cycle, to determine whether the systems are responding to the temperature controls. Thermostat settings, thermostat temperature readings, and an independent temperature measurement at the thermostat shall be recorded at each thermostat. If the tests on both the heating and cooling cycles can not be made together because of the time of the year, the test not made shall be performed later when conditions are acceptable. A supplement to the final report shall be filed when later tests are made.
- B. Test Verification - The TAB agency shall attest by letter that all equipment has been wired and tested to see that the indicated sequence of motor control is established, that all safety controls function properly, that all motor protective devices are sized correctly, and that the systems are operating at the points set on the controls.
- C. Control Setting - During the performance tests, control settings may require adjustment and if so, shall be adjusted to produce the best balanced system operation. The final setting of each operating and safety control shall be recorded. This shall include but not be limited to thermostats, limit controls, damper position switches, smokestats, firestats, freezestats, aquastats, and other similar items.
- D. Marking of settings - Upon completion of system balancing the settings of adjustment devices including valves and dampers shall be permanently marked. Do not mark room mounted thermostats.

**3.5 COMMISSIONING**

- A. Upon completion of the Testing Adjusting and Balancing for HVAC, the TAB Contractor shall allow for up to eight (8) hours for TAB verification to be coordinated by and with the CxA.

END OF SECTION 230593

## SECTION 230700 - HVAC INSULATION

### PART 1 - GENERAL

#### 1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

#### 1.2 DESCRIPTION OF WORK

- A. The work to be performed under this section of the specifications comprises the furnishing of all labor and materials and the completion of all work of this section as shown on the drawings and/or herein specified.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.
- C. In general, the work included under this section consists of, but is not limited to, the following:
  - 1. Field applied insulation for thermal efficiency and condensation control for HVAC and plumbing piping, ductwork and equipment.

#### 1.3 RELATED WORK

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 232000, HVAC PIPING AND PUMPS.
- C. Section 233000, HVAC AIR DISTRIBUTION.
- D. Section 238200, CONVECTION HEATING AND COOLING UNITS.

#### 1.4 SUBMITTALS:

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements, furnish the following:
  - 1. Manufacturer's Literature and Dimension Cuts:
    - a. Insulation Materials: Each type used. State surface burning characteristics and thermal properties.
    - b. Insulation Facings and Jackets: Each type used. State vapor barrier properties. State that white finish will be furnished for exposed pipe, ductwork, casings, and equipment.
    - c. Insulation Accessory Materials: Each type used.

- d. Manufacturer's installation and fitting fabrication instructions for elastomeric unicellular insulation.
- e. Make reference to applicable specification paragraph numbers for coordination.

## 1.5 DEFINITIONS

- A. Air Conditioned Space: Space directly supplied with cooled air.
- B. Cold: Equipment, ductwork or piping handling media at design temperature of 60 Deg. F. or below.
- C. Hot: Ductwork handling air at design temperature above 60 Deg. F.; equipment or piping handling media above 105 Deg. F.
- D. PCF: Density, pounds per cubic foot.
- E. VOC's: Volatile Organic Compounds
- F. Runout: Branch pipe connection up to one inch nominal size and not over 12 feet in length to a floor mounted or ceiling mounted terminal unit.
- G. Thermal Conductance: Heat flow rate through materials.
  - 1. Flat Surface: BTU per hour per square foot.
  - 2. Pipe or Cylinder: BTU per hour per linear foot.
- H. Thermal Conductivity (k):  $(\text{BTU} \cdot \text{in thickness}) / (\text{hr} \cdot \text{ft}^2 \cdot ^\circ\text{F temperature difference})$ .
- I. Outside: Open to view beyond the exterior side of walls, above the roof and unexcavated or crawl spaces, above or beneath pier floors, in tunnels or exposed on all sides in trenches connected or not connected to an exterior portion of a building.
- J. Finished Spaces: Spaces used for habitation or occupancy where rough surfaces are plastered, paneled, or otherwise treated to provide a pleasing appearance.
- K. Unfinished Spaces: Spaces used for storage or work areas where appearance is not a factor, unexcavated spaces, crawl spaces, etc.
- L. Concealed Spaces: Spaces between a ceiling and floor construction above or between double walls or furred-in areas, pipe and duct shafts, etc.
- M. Exposed: Open to view inside the building. For example, pipe run through a room, and not covered by other construction, is exposed.

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. Building characteristics of insulation materials shall comply with NFPA 90A, pertinent parts of which are noted as follows:
  - 1. Duct coverings, duct linings, vapor barrier facings, tapes, and core materials in panels used in duct systems shall have a flame spread rating not over 25 without evidence of continued progressive combustion and a smoke developed rating not higher than 50. If coverings and linings are to be applied with adhesives, they shall be tested as applied with such adhesives, or the adhesives used shall have a flame spread rating not over 25 and a smoke developed rating no higher than 50 when in the final dry state.
  - 2. Duct coverings and linings shall not flame, glow, smolder, or smoke when tested in accordance with ASTM C 411 at the temperature to which it is exposed in service. In no case shall the test temperature be below 250 Deg. F.
  - 3. Pipe insulation and coverings shall meet the requirements of 2-3.3.1 and 2-3.3.2 when installed in ducts, plenums, or concealed spaces used as part of the air distribution system.
  - 4. In addition to NFPA, the insulation material shall not transform into a molten flaming liquid during combustion as characterized by some polyethylenes.
- B. Test Methods: ASTM E 84, UL 723, or NFPA 255.
- C. Insulation shall be Johns Manville, Owens Corning, Pittsburg Corning, or Armacell. Trade names are used herein, unless indicated otherwise, to establish a standard of quality.
- D. Specified k factors are at 75 Deg. F. mean temperature unless stated otherwise. Where optional insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For a flat surface, thermal conductance equal thermal conductivity (k) divided by the thickness of the insulation. For runout insulation and condensation control insulation, no thickness adjustment need be made.
- E. All materials shall be compatible and suitable for service temperature and shall not contribute to corrosion or otherwise attack surfaces to which applied in either the wet or dry state.
- F. Underwriters' Laboratories, Inc. label or listing, or satisfactory certified test report from an approved testing laboratory will be required to show that surface burning characteristics for materials to be used do not exceed specified ratings.
- G. All sealants and adhesives must comply with all applicable South Coast Air Quality Management District (SCAQMD) VOC limits including but not limited to Rule #1168. All mastics and coatings must comply with all applicable Green Seal GS-11 VOC limits.

### 2.2 FACINGS AND JACKETS

- A. Fed. Spec. HH-B-100 for Vapor Barrier Types I and II:
  - 1. Puncture Test Method: ASTM D 781.

2. Type I, Low Vapor Transmission (0.02 Perm Rating), Beach Puncture 50 Units: For insulating facing on exposed ductwork, casings, and equipment, and for all pipe insulation jackets. Facings and jackets shall be white all service type (ASJ) suitable for painting without priming.
3. Type II, Medium Vapor Transmission, Beach Puncture 25 Units: Foil-Scrim-Kraft (FSK) type for concealed ductwork and equipment.
4. Factory composite materials may be used provided they have been tested and certified by the manufacturer to meet Beach puncture units specified above.
5. Fire and smoke treatment of jackets and facings shall be permanent. The use of water soluble treatments is not acceptable.
6. Pipe insulation jackets shall have 1-1/2 inch minimum lap at longitudinal joints and not less than 3-inch butt strips at end joints. Facing on board, blanket and block insulation shall have 2-inch laps or 3-inch minimum butt strips. Butt strip material shall be the same as the jacket or facing. Laps and butt strips may be self-sealing type with factory applied pressure sensitive adhesive.

### 2.3 MINERAL FIBER INSULATION

- A. Owens-Corning Faced Duct Wrap Fiberglass Insulation - FRK Type 100, ASTM C 553-92 (Blanket, Flexible), Density 1 pcf,  $k = 0.31$ , for temperatures up to 250 Deg. F.
  1. Concealed supply air ductwork within building's thermal envelope shall be 1-1/2 inch thick insulation.
  2. Concealed outdoor air ductwork within building's thermal envelope shall be 2-inch thick insulation.
  3. Concealed supply air ductwork outside building's thermal envelope shall be 2-inch thick insulation.
  4. Concealed return air ductwork within building's thermal envelope need not be insulated.
  5. Concealed exhaust air ductwork within building's thermal envelope and within 10 feet of connection to outdoors shall be 1-1/2 inch thick insulation.
  6. Concealed exhaust air ductwork outside building's thermal envelope shall be 1-1/2 inch thick insulation.
- B. Owens-Corning 705 Rigid Board Fiberglass Insulation, ASTM 612, 6 pcf density, with white laminated kraft-aluminum foil reinforced all-service vapor barrier facing.
  1. Exposed outside air ductwork shall be 2-inch thick insulation.
  2. Exposed supply air ductwork shall be 1-1/2 inch thick insulation.
  3. Exposed return air ductwork and exhaust air ductwork in non-air conditioned spaces shall be 1-1/2 inch thick insulation.
  4. Exposed ductwork with acoustic lining need not be insulated.
- C. Owens-Corning Fiberglass SSL II ASJ Heavy Density Sectional Pipe Insulation, Fed. Spec. HH-I-558, Form D, Type III (Molded), Class 12,  $k = 0.24$ .
- D. Molded pipe fitting covering: Fed. Spec. HH-I-558, Form E. Class 16,  $k = 0.26$ , for temperatures up to 370 Deg. F.
- E. Insulation thickness and type for various piping systems shall be as indicated in the following table (Pipe Size/Insulation Thickness).



PIPE SIZE/INSULATION THICKNESS(1)

System	Temp. Range (°F)	Less than 1"	1" to 1-1/4"	1-1/2" to 3"	4" to 6"	8" & Up	Ins. Type (4)
High Pressure Steam	351-450	4.5	5.0	5.0	5.0	5.0	A
Medium Pressure Steam	251-350	3.0	4.0	4.5	4.5	4.5	A
Low Pressure Steam	201-250	2.5	2.5	2.5	3.0	3.0	A
Heating Water	140-200	1.5	1.5	2.0	2.0	2.0	A
Domestic Hot Water	90-159	1.5	1.5	2.0	2.0	2.0	A
Misc.	80-89	1.0	1.0	1.0	1.0	1.0	A,B
Domestic Cold Water	56-79	1.0	1.0	1.0	1.0	1.0	A
Chilled Water	40-55	1.0	1.0	1.5	1.5	2.0	A
Condensate Drain	45-75	0.5	0.5	1.0	1.0	1.0	A,B
Steam Condensate	Any	1.5	1.5	2.0	2.0	2.0	A
Horizontal Soil (2)	Any	---	---	1.0	1.5		A
Horizontal Storm (3)	Any	---	---	1.0	1.5		A

**NOTES:**

- (1) Minimum thickness for insulation listed in preceding table is based on Thermal Conductivity, 'k' not exceeding 0.27 Btu per inch/hr. x sq. ft. x Deg. F. based on Mean Temperature of 75 Deg. F. Insulation with greater Thermal Conductivity shall have increased thickness to provide same performance characteristics as specified.
- (2) All horizontal sanitary piping above Kitchen or Dining Area only.

- (3) All horizontal storm piping above lowest floor including roof drains from underside of deck to just below fitting at top of vertical portion of stack. Fittings at top and bottom of vertical sections of horizontal offsets shall be insulated. Lap joints, tape and seal.
- (4) A - Fiberglass type insulation; B - Elastomeric type insulation.
- (5) Runouts to individual terminal units (not exceeding 12 ft. in length).
- (6) Also insulate all refrigerant pipes located in hot spaces such as attics.

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## 2.4 ELASTOMERIC INSULATION

- A. Armstrong Armaflex II Pipe Insulation, Fed. Spec. HH-I-573 and HH-I-1751/2, k = 0.27, flame spread not over 25, smoke developed not over 50 (1/2-inch thick test material), for temperatures from minus 40 Deg. F. to 211 Deg. F. No jacket required.

## 2.5 CELLULAR GLASS INSULATION

- A. Pittsburgh Corning Foamglas Insulation, ASTM C 552, Type II, class 2, 8.5 pcf, closed cell rigid type.
  1. Buried steam piping, not in conduit, shall have 2 inch thick insulation.
  2. Buried pumped condensate piping, not in conduit, shall have 1 inch thick insulation.
  3. Outside piping shall have insulation thickness as indicated in table or as indicated on drawing. Protect with aluminum jacket.

## 2.6 ACCESSORY MATERIALS

- A. Insulation inserts at pipe supports:
  1. Material: Cellular glass or calcium silicate 1/2 section of insulation, same thickness as adjacent insulation.
  2. Provide inserts for all insulated piping greater than 1-1/2 inch diameter. Install with metal insulation shields furnished with pipe supports, Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) General Requirements. Minimum insert length: 10 inches for up to 3 inch pipe, 12 inches for 3 to 6 inch pipe, 16 inches for 8 to 10 inch pipe, and 22 inches for pipe 12 inches and larger.
- B. Adhesives, Mastics, Cement:
  1. Mil. Spec. MIL-A-3316B, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
  2. Mil. Spec. MIL-A-3316B, Class 2: Adhesive for laps for adhering insulation to metal surfaces.
  3. Mil. Spec. MIL-A-24179A, Type II, Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
  4. Mil. Spec. MIL-B-19565B, Type 1 or Type II and be listed on Qualified Products Database (QPD): Vapor barrier compound for outdoor use.
  5. Fed. Spec. SS-C-160A, Type IIIB, (ASTM C 449): Mineral fiber hydraulic-setting thermal insulating and finishing cement.
  6. Other: Insulation manufacturer's published recommendations.

- C. Mechanical Fasteners:
1. Pins, Anchors: Welded pins, or metal or nylon anchors with tin-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
  2. Staples: Outward clinching monel or stainless steel.
  3. Wire: 18 gage soft annealed galvanized, or 14 gage copper clad steel or nickel copper alloy.
  4. Bands: 3/4-inch nominal width, brass, aluminum or stainless steel.
- D. Reinforcement and Finishes:
1. Glass Fabric, Open Weave: ASTM D 1668, Type III (resin treated) and Type 1 (asphalt treated).
  2. Glass Fiber Fitting Tape: Mil. Spec. MIL-C-20070, Type II, Class 1.
  3. Tape for Flexible Unicellular Insulation: Scotch No. 472, Nashua PE-12, or approved equal recommended by the insulation manufacturer.
  4. PVC Fitting Cover: Fed. Spec. L-P-535D, Composition A, Type II, Grade GU, with Form B mineral fiber insert, for media temperature 45 Deg. F. to 250 Deg. F. Below 45 Deg. F. and above 250 Deg. F., provide double layer insert. Provide color matching, vapor barrier, pressure sensitive tape.
- E. Firestopping Material: Refer to Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Required pressure tests of joints and connections shall be completed before application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale, and rust removed.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use necessary means to protect his work and materials.
- C. Except for specific exceptions, insulate entire specified equipment, piping, and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- D. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor barriers shall be continuous and uninterrupted throughout systems with operating temperature 60 Deg. F. and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports, and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of six inches.

- E. Insulation on hot piping and equipment shall be terminated square or beveled with insulating cement, covered with jacket, at items not to be insulated, access openings and nameplates.
- F. On cold systems, vapor barrier performance is extremely important. Particular care must be given to vapor sealing the fitting cover or finish to the insulation vapor barrier. All penetrations of the jacket and exposed ends of insulation must be sealed with vapor barrier mastic. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion.
- G. HVAC Work Not To Be Insulated:
  - 1. Internally insulated ductwork and air handling units.
  - 2. Equipment: Heating water pumps, expansion tanks.
  - 3. In Hot Piping: Unions, flexible connectors, control valves and discharge vent piping.
  - 4. Factory insulated flexible ducts.
  - 5. Factory insulated supply air diffusers.
- H. Plumbing Work Not To Be Insulated:
  - 1. Piping and valves of fire protection system.
  - 2. Chromium plated brass piping (except hot water and drain piping under handicapped lavatories).
  - 3. Domestic Hot Water: Unions, flexible connectors, control valves, expansion tank, pump.
- I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastics and coatings at the manufacturer's recommended minimum coverage.

### 3.2 INSTALLATION

- A. Flexible Mineral Fiber Blanket:
  - 1. Adhere insulation to metal with 4-inch wide strips of insulation bonding adhesive at 8 inches on center. Additionally secure insulation to bottom of ducts exceeding 24 inches in width with pins welded or adhered 18 inches on centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor barrier penetrations with vapor barrier mastic. Sagging duct insulation will not be acceptable.
  - 2. Supply air ductwork to be insulated includes main and branch ducts from fan discharge to room supply outlets and the bodies of ceiling outlets to prevent condensation. To prevent condensation, insulate trapeze type supports and angle iron hangers for flat oval ducts.
- B. Molded Mineral Fiber Pipe and Tubing Covering:
  - 1. Fit insulation to pipe aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor barrier penetrations with vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports.
  - 2. Fittings, Flange and Valve Insulation:

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- a. Fiberglass Pipe insulation shall be installed with joints butted firmly together. Valves and devices requiring access shall be insulation with mitered sections of insulation equal in thermal resistance and thickness to the adjoining insulation. Fittings shall be covered with Schuller "Zeston" type, pre-molded PVC fitting covers. Jackets on pipe insulation shall be stapled using outward clinching type staples spaced 3" apart at least 1/4" from the lap edge on systems operating at 80 Deg. F. and above; below 80 Deg. F. the laps are to be vapor sealed using self-sealing lap, lap seal gun, or adhesive. All insulation elbows, fittings, flanges, joints, laps, voids, punctures, and end tapers shall be sealed with two coats of Foster Vapor Out 30-33 or Childers Chil Out CP-33 vapor barrier mastic and reinforcing mesh (total 35 mils or 0.9 mm dry film thickness) regardless of service and before Zeston covers are applied.
  - b. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least two inches.
- C. Elastomeric Insulation:
1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions.
  2. Pipe and Tubing Insulation:
    - a. Use proper size material. Do not stretch or strain insulation.
    - b. To avoid undue compression of insulation, provide inserts at supports as recommended by the insulation manufacturer. Insulation shields are provided under Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
    - c. Elastomeric insulation shall be slipped on the pipe prior to connection wherever possible. Pipe leak tests shall be performed prior to the insulation of fittings. Where the slip-on technique is not possible longitudinal slit insulation shall be snapped on the pipe. All seams, voids, and butt joints shall be sealed with a Foster 85-75 or Childers CP-82 vapor barrier adhesive or taped with 1-1/2 inch wide 3M #471 tape.
    - d. Fittings and valves shall be insulated with mitered sections of insulation. All joints shall be secured and sealed with vapor barrier adhesive. Approved factory-made fittings such as F & D Mfgr. and Supply Co. may be used.
  3. On exterior refrigerant suction piping, provide two coats of Armstrong Armaflex Finish (vinyl lacquer) or Foster 30-64 on the insulation.
- D. Rigid Mineral Fiber Board: Secure rigid insulation by impaling over pins or anchors located not more than 3 inches from edge of boards and spaced not more than 18-inch centers and secured with washers and clips. Spot-weld anchor pins or attach with a Foster 85-60 or Childers CP-127 adhesive especially designed for use on metal surfaces. Apply insulation with joints tightly butted. Where vapor barrier is specified, all joints, breaks, seams, punctures, and voids shall be filled with vapor barrier mastic and covered with vapor seal material identical to that surrounding. Neatly bevel insulation around name plates and access plates and doors. Each pin or anchor shall be capable of supporting a 20-pound load. Protruding ends of clips shall be cut off flush after clips are secured and sealed with aluminum backed pressure sensitive tape and coated with vapor barrier mastic.

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- E. Duct-mounted heating coils and variable air volume terminal box heating coils shall be insulated with external duct insulation as specified for cold systems. Where adjacent duct or unit is internally lined, extend external insulation minimum 2" onto adjacent item. Completely vapor seal insulation around coil and seal to adjacent surface.
- F. Hot piping serving heating coils located downstream from cooling coils including remote duct-mounted coils, coils at terminal units, etc., shall be insulated a minimum of 5 feet from the coil connection as specified for cold piping. All valves, flanges, unions, flexible connections, etc., within the insulated length shall also be insulated.
- G. Kitchen Hood: Kitchen exhaust ducts carrying grease-laden air shall be insulated with Flameshield Blanket (FSB) fire proofing as manufactured by ETS Schaefer or equal. Insulation shall be 6 pounds per cubic foot density and 1-1/2 inch thick with foil scrim outer cover. Insulation shall be applied in two layers and secured as recommended by manufacturer to provide a 2-hour rated enclosure with zero clearance to combustibles. The insulation shall meet UL 1978 and ASTM E-814(UL-1479) for test compliance.
- H. Heaters and Tanks: Domestic water heaters, hot water storage tanks, and converters shall be insulated with 1-1/2" thick Hydrous calcium silicate blocks with edges tightly butted and secured with 1/2 x .015" thick galvanized steel bands not over 12" on center. Finish with Schuller No. 375 insulating cement troweled on in two 1/2" thick coats over chicken wire. Last coat shall be mixed 2-to-1 by weight with Portland cement and shall be troweled smooth.
- I. Chilled water pumps shall be insulated with removable and replaceable cover of 20 gage galvanized sheet metal jacket lined with fiberglass insulation having an 'R' value of 4.0 per inch of thickness at a mean temperature of 75 Deg. F. All voids between metal cover and pump housing shall be filled with insulation. Metal cover shall be vapor sealed with Foster 95-44 or Childers CP-76 sealant after the covers are in place.
- J. Roof Drain: The bottom of each roof drain, including deck clamps, shall be insulated with 1" thick fiber glass flexible insulation with an 'R' value of 4.16 with 1 mil foil-scrim-kraft paper jacket. Insulation shall be held securely in place with tape. Joints shall be lapped. Joints, voids, and punctures in the jacket shall be effectively vapor sealed with Foster Vapor Out 30-33 or Childers CP-33 Chil Out.

END OF SECTION 230700

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section and the Contractor is cautioned to read Section 230000 carefully, especially paragraph 2.3 Motors, Control and Electrical Wiring as items of work applicable to this section.

1.2 RELATED WORK:

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC
- C. Section 232000, HVAC PIPING AND PUMPS
- D. Section 233000, HVAC AIR DISTRIBUTION.
- E. Section 238200, CONVECTION HEATING AND COOLING UNITS.
- F. NOTE: The technical specifications are arranged for convenience and such arrangement shall not operate to make the Architect/Engineer an arbiter in establishing the limits of any subcontract or trade.

1.3 WORK INCLUDED

- A. Controls for new mechanical equipment shall be an extension of the existing Siemens Dietrick Building Automation System in keeping with the VT standards. Existing Dietrick BAS network protocol shall be extended to the new BAS controllers provided for this work. Include updated graphics on the existing Siemens central server in Sterrett Complex

1.4 APPROVED MANUFACTURERS

- A. Furnish and install automatic temperature controls (ATC) as shown on the contract drawings and hereinafter specified, to ensure that once the chilled water system is complete, systems will be fully functional. System shall be an extension of the existing Siemens Industry, Inc. controls system network. Provide all equipment and materials as required to accomplish the Sequence of Control. Manufacturer shall be Siemens Building Industry, Inc. only. Installer's qualifications requires firms specializing and experienced in electric/electronic control system installations for not less than 3 years. Provide electrical products which have been tested, listed and labeled by UL and comply with NEMA standards. Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

## 1.5 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable. The manufacturer shall provide full time, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS system.
- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- C. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
- D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- E. Control system shall be engineered, programmed and supported completely by representative's local office that must be within 100 miles of project site.

## 1.6 REFERENCE STANDARDS

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
  - 1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
  - 2. ANSI/ASHRAE Standard 135-2001, BACnet.
  - 3. Uniform Building Code (UBC), including local amendments.
  - 4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
  - 5. National Electrical Code (NEC).
  - 6. FCC Part 15, Subpart J, Class A
  - 7. EMC Directive 89/336/EEC (European CE Mark)
  - 8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences
- B. City, county, state, and federal regulations and codes in effect as of contract date.
- C. Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.



## 1.7 SUBMITTALS

### A. Drawings:

1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
2. Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).
3. An electronic pdf set of submittal drawings shall be provided.
4. Provide detail of faces of control panels, sensors, and thermostats.

### B. System Documentation - Include the following in submittal package:

1. System configuration diagrams in simplified block format.
2. All input/output object listings and an alarm point summary listing.
3. For all system elements—application controllers, routers, and repeaters,—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
4. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.

## 1.8 WARRANTY

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.
- C. This warranty shall apply equally to both hardware and software.

## PART 2 - PRODUCTS

### 2.1 FAN COIL UNIT CONTROLLERS

- A. Provide one native BACnet application controller for each fan coil unit that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.
- B. BACnet Conformance:
  1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

**Renovate First Floor of Dietrick Hall and Plaza**

Virginia Polytechnic Institute and State University

Project Code 208-L00050-000

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- a. Files Functional Group
  - b. Reinitialize Functional Group
  - c. Device Communications Functional Group
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
  3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure independent control algorithms and all flow readings shall be in CFM (LPS if metric).
- D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator workstation section. All programming tools shall be provided as part of system.
- E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.
- F. On board flow sensor shall be microprocessor driven and precalibrated at the factory. Precalibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration.
- G. Provide duct temperature sensor at discharge of each terminal box that is connected to controller for reporting back to operator workstation.

## 2.2 SENSORS and MISCELLANEOUS DEVICES

- A. Temperature Sensors: All temperature sensors to be solid state electronic, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Thermostats shall be capable of providing a temperature range or deadband of at least 5°F within which the supply of heating and cooling energy to the zones is capable of being shut off or reduced to a minimum. Wall sensors to be installed as indicated on drawings. Mount 48 inches about finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake and in a location that is in the shade most of the day.
- B. Carbon Dioxide Detector:
1. Duct mounted CO<sub>2</sub> sensors shall be Vaisala Carbocap carbon dioxide transmitter for duct mounting complete with: 24 VDC or 24 VAC input power; selectable 0 to 20 mA, or 0 to 10 VDC output signal corresponding to 0 to 2000 PPM CO<sub>2</sub>. Model number: GMD20, or equivalent Vaisala transmitter.
  2. Carbocap carbon dioxide transmitter for wall mounting complete with: 24 VDC or 24 VAC input power; selectable 0 to 20 mA, or 0 to 10 VDC output signal corresponding to 0 to 2000 PPM CO<sub>2</sub>. Model number: GMW20, or equivalent Vaisala transmitter. Accuracy: Within plus or minus 10 percent.
- C. Network Connection Tool:
1. Network connection tool shall allow technician to connect a laptop to any MS/TP network or at any MS/TP device and view and modify all information throughout the entire BACnet network. Laptop connection to tool shall be via Ethernet or PTP.
  2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in the BACnet standard.

## 2.3 ELECTRONIC ACTUATORS AND VALVES

- A. Quality Assurance for Actuators and Valves:
1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
  2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
  3. Five-year manufacturers warranty. Two-year unconditional and three-year product defect from date of installation.
- B. Execution Details for Actuators and Valves: Each DDC analog output point shall have an actuator feedback signal, independent of control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status.
- C. Actuators for Damper and Control Valves ½" to 6" shall be Electric unless otherwise specified, provide actuators as follows:

1. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify Actuators.
2. NEMA 2 rated actuator enclosures are. Use additional weather shield to protect actuator when mounted outside.
3. 5 year Manufacturers Warranty. Two-year unconditional + Three year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the Actuator.
6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.
7. A push button gearbox release shall be provided for all non-spring actuators.
8. Modulating actuators shall be 24Vac and consume 10VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators:

1. Outside Air and Exhaust Air Damper Actuators shall be Mechanical Spring Return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. Economizer Actuators shall utilize Analog control 2-10 VDC, Floating control is not acceptable.
3. Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
4. One electronic actuator shall be direct shaft mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section. (See below execution section for more installation details.)

E. Valve Actuators ½" to 6":

1. Mechanical spring shall be provided on all actuators for pre-heat coil and actuators for AHU heating or cooling coil when units are mounted outside. See plans for fail save flow function: Normal Open or Normal Closed. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
2. All zone service actuators shall be non-spring return unless otherwise specified.
3. The valve actuator shall be capable of providing the minimum torque required for proper valve close off for the required application.
4. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
5. Override handle and gearbox release shall be provided for all non-spring return valve actuators.

- F. Control Dampers. The BAS contractor shall furnish and size all automatic control dampers unless provided with packaged equipment. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
1. All dampers used for modulating service shall be opposed blade type arrange for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
  2. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
  3. Damper linkage hardware shall be constructed of aluminum or corrosion resistant zinc & nickel-plated steel and furnished as follows:
  4. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.
  5. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For Single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
  6. Damper manufacturer shall supply alignment plates for all multi-section dampers.
- G. Control Valves ½" to 6": The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The Plumbing contractor shall install all valves. Equal Percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves 2½ inch and above.
1. Characterized Control Valves shall be used for hydronic heating or cooling applications and small to medium AHU water coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the Outside Air stream then see plans for Spring Return requirement.
    - a. Leakage is Zero percent, Close-off is 200psi, Maximum differential is 30psi. Rangeability is 500:1.
    - b. Valves 1/2 inch through 2 inches shall be nickel-plated forged brass body, NPT screw type connections.
    - c. Valves 1/2 inch through 1-1/4 inches shall be rated for ANSI Class 600 working pressure. Valves 1-1/2 inch and 2 inches shall be rated for ANSI Class 400 working pressure.
    - d. The operating temperature range shall be 0° to 250° F.
    - e. Stainless steel ball & stem shall be furnished on all modulating valves.
    - f. Seats shall be fiberglass reinforced Teflon.
    - g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
    - h. Three-way valve shall be applicable for both mixing and diverting.
    - i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
    - j. The valves shall have a blow out proof stem design.
    - k. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.



- B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

### 3.3 LOCATION AND INSTALLATION OF COMPONENTS

- A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.
- B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.
- C. Identify all equipment and panels. Provide permanently mounted tags for all panels.
- D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections—sized to suit pipe diameter without restricting flow.

### 3.4 INTERLOCKING AND CONTROL WIRING

- A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 16 and all national, state and local electrical codes.
- B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.
- C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.
- D. Provide auxiliary pilot duty relays on motor starters as required for control function.
- E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings—coordinate with electrical contractor.
- F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).

### 3.5 DDC OBJECT TYPE SUMMARY

- A. Provide all database generation.
- B. Displays: System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

- C. Trendlog: All binary and analog object types (including zones) shall have the capability to be automatically trended.
- D. Alarm: All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.
- E. Database Save: Provide back-up database for all stand-alone application controllers on disk.

### 3.6 FIELD SERVICES

- A. Prepare and start logic control system under provisions of this section.
- B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for 1 year or as specified.
- D. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

### 3.7 TRAINING

- A. Provide application engineer to instruct owner in operation of systems and equipment.
- B. Provide system operator's training to include (but not limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of 3 persons.
- C. Provide on-site training above as required, up to 16 hours as part of this contract.

### 3.8 DEMONSTRATION

- A. Provide systems demonstration under provisions of Section 15010.
- B. Demonstrate complete operating system to owner's representative.
- C. Provide certificate stating that control system has been tested and adjusted for proper operation.



## PART 4 - SEQUENCE OF OPERATIONS

### 4.1 GENERAL

- A. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they will be provided.
- B. BACnet Object List: The following points as defined for each piece of equipment are designated as follows:
  - 1. Binary Out (BO) - Defined as any two-state output (start/stop) (enable/disable), etc.
  - 2. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
  - 3. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
  - 4. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.

### 4.2 CONTROL SEQUENCES

- A. Fan Coil Units (FC-):
  - 1. General: Each fan coil unit shall be controlled and monitored as directed by the wall-mounted digital temperature sensor. Unit controller shall be provided for each fan coil unit and wired to the 24V terminal strip provided by the Fan Coil Unit manufacturer. Unit controller shall be suitable for simultaneously controlling the fan coil unit and the associated baseboard heating (where applicable).
  - 2. The unit controller shall perform the following fan coil control strategies and provide the specified monitoring and diagnostics:
    - a. Fan Operation: The supply fan shall cycle on/off and vary speed to maintain set-point within the room.
    - b. Four Pipe Valve Control: In heating mode, the BAS shall energize the steel panel radiation as the first stage of heating. The BAS shall modulate the heating water valve to maintain space temperature. If space set-point cannot be achieved after 10 minutes (adjustable), the BAS shall energize the associated fan coil unit(s) to modulate the heating valve and the unit fan to maintain the heating set-point temperature (adjustable) and the cooling valve shall be fully closed. In cooling mode, the cooling valve shall be modulated to maintain the cooling set-point (adjustable) and the heating valve shall be fully closed. In either mode, the discharge air temperature set-point shall be limited to an adjustable low (50 Deg. F. adjustable) and high (90 Deg. F. adjustable) to prevent extremely cold or hot air from blowing into the space.
    - d. A condensate overflow switch shall shut off the fan coil unit fan and close the chilled water valve if the high condensate level trips the switch.
    - e. Occupied mode space temperature set-points shall be 75 Deg. F in cooling and 72 Deg. F in heating (adjustable, confirm with Owner). Unoccupied mode set-points

shall be 80 Deg. F in cooling and 65 Deg. F in heating (adjustable, confirm with Owner). The controls shall be capable of automatically adjusting the daily start time of the unit in order to bring the space to the desired occupied temperature immediately prior to scheduled occupancy.

B. Ionization System (AHU-1, 2, 3, 4, & 5):

1. Occupied Mode: When the existing air handling unit is commanded to occupied, as determined by the existing BAS, the BAS shall energize the ionization system to run continuously.
2. Un-Occupied Mode: When the existing air handling unit is commanded to unoccupied, as determined by the existing BAS, the BAS shall de-energize the ionization system.
3. Ion Detector: The BAS shall monitor ionization levels in the associated systems air via the Ion Detector.
4. Alarms: The BAS shall monitor the ionization system status for each air handler and alarm of off-normal conditions.

C. Steel Panel Radiation (SPR-)

1. Except as noted for the new steel panel radiation associated with the new Fan Coil Units, the existing baseboard heating shall follow the Owner's existing sequence of operation. The BAS shall energize the baseboard heat and steel panel radiation based on outside air temperature (adjustable). The BAS shall modulate the heating water valves for steel panel radiation serving the vestibules to maintain space temperature set-point (adjustable). The programming shall include the option to switch to the outside air temperature control sequence in lieu of the space sensor control strategy at the Owner's discretion.

D. Fire Pit (Refer to Plumbing and Site Plans)

1. The BAS shall enable/disable the Fire Pit systems based on an Owner provided time of day schedule (adjustable). Provide point quantity as required for each fire pit ignition system.

4.3 POINT LISTS

- A. The following point lists are provided as a minimum basis for control. Other points shall be provided as required to accomplish the Control Sequences and to provide a complete control system for automatic and safe control of the HVAC equipment.
- B. See attached pages.

## SECTION 232000 - HVAC PIPING AND PUMPS

### PART 1 - GENERAL

#### 1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

#### 1.2 DESCRIPTION OF WORK

- A. Piping to connect HVAC equipment, including the following:
  - 1. Condensate Piping
  - 2. Heating Water Piping
  - 3. Chilled Water Piping
  - 4. Condensate Drain Piping
- B. Installation of control valves and instrument wells referred to in other Division 23 sections.
- C. Hydronic System Components
- D. End Suction Pumps
- E. Suction Diffuser

#### 1.3 RELATED WORK

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230548, VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.
- C. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- D. Section 230700, HVAC INSULATION.
- E. Section 230900, INSTRUMENTATION AND CONTROL FOR HVAC.
- F. Section 233000, HVAC AIR DISTRIBUTION.
- G. Section 238200, CONVECTION HEATING AND COOLING UNITS.

#### 1.4 SUBMITTALS

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
1. Manufacturer's Literature and Data with pump curve (where applicable):
    - a. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers
    - b. Pipe and tubing, with specification, class or type, and schedule
    - c. Pipe fittings, including miscellaneous adapters and special fittings
    - d. Flanges, gaskets and bolting
    - e. Valves of all types
    - f. Strainers
    - g. Gages
    - h. Flexible connectors for water service
    - i. All specified hydronic system components
    - j. Water flow measuring devices
    - k. Underground piping system
    - l. Thermometers and tests wells
    - m. End Suction Water Pumps
    - n. Suction Diffuser
- B. Manufacturer's Certified Data Report for ASTM Pressure Vessels:
1. Air separators.
  2. Expansion tanks.

## PART 2 - PRODUCTS

### 2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

- A. Provide in accordance with specifications in Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

### 2.2 PIPE AND TUBING

- A. Heating Water Piping and Chilled Water Piping (2-1/2 Inch and Larger):
1. Black Steel: ASTM A 53 Schedule 40 standard weight.
- B. Heating Water Piping and Chilled Water Piping (2-Inch and Smaller):
1. Black Steel: ASTM A 53 Schedule 40 standard weight.
  2. Copper Water Tube Option: ASTM B 88, Type L, hard drawn. Except underground lines shall be Type K hard drawn copper tubing.
- C. Extension of Domestic Water Make-Up Piping: ASTM B 88, Type L, hard drawn copper tubing.

- D. Cooling Coil Condensate Drain Piping--from Air Handling Units: Copper water tube, ASTM B 88, Type L, hard drawn copper tubing.
- E. Heating water piping installed below ground and within concrete slabs at the vestibules shall be UPONOR, REHAU, or Rhinoflex pre-insulated PEX-a piping with multi-layer, closed cell PEX-foam insulation and corrugated HDPE jacket with engineered polymer polyphenylsulfone F1960 cold-expansion fittings. Piping shall be hydrostatically rated for 180°F at 100 psi and shall conform to ASTM F876, ASTM F877, CSA B137.5. Fittings and accessories shall be by the same manufacturer and shall be compatible with the piping system. End seals shall be manufacturer supplied EPDM rubber end caps with water stop seal. Cold expansion fittings shall be barbed adapter type and manufactured in accordance with ASTM F1960 and comply with ASTM F877. Compression fittings shall be of dezincification resistant, lead free brass and shall consist of a coupling sleeve, fitting body insert with o-ring, and a bolt and nut. Plastic to metal transition fittings and unions shall be provided by the same manufacturer of the piping and as required to connect to metal distribution piping above grade. Fittings shall be brass sweat, threaded, or compression type with reinforcing cold expansion ring. All piping shall be installed in strict accordance with the piping manufacturer's recommendations. PEX-a piping and ASTM F 1960 fittings shall be 25years with 5 year manufacturer warranty for pre-insulated pipe distribution system. Warranty covers repair and replacement of any pipe or fittings proven defective.

### 2.3 FITTINGS FOR STEEL PIPE

- A. 2-1/2 Inch and Larger: Welded, flanged, or grooved joints suitable for 125 psi service.
  - 1. Butt Weld Fittings: ANSI B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type unless otherwise noted.
  - 2. Welding Flanges and Bolting: ANSI B16.5.
    - a. Water Service: Weld neck or slip-on plain face, with 1/8-inch thick full face neoprene gasket suitable for 220 Deg. F.
    - b. Flange Bolting: Carbon steel machine bolts or studs and nuts, ASTM A 307, Grade B.
    - c. Grooved: ASTM A-536 ductile iron couplings, ASTM A-153 galvanized, Victaulic Style 77.
      - (1) Heating water gasket suitable for 230 Deg. F continuous service.
      - (2) Chilled water gaskets shall be suitable for the intended service.
      - (3) Steam service not applicable.
- B. 2-Inch and Smaller: Threaded or welded, suitable for 125 psi service.
  - 1. Butt Welding: ANSI B16.9 with same wall thickness as connecting piping.
  - 2. Forged Steel, Socket welding or Threaded: ANSI B16.11.
  - 3. Threaded: 150 pound malleable iron, ASTM B16.3. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
  - 4. Unions: Fed. Spec. WW-U-531.
  - 5. Water Hose Connection Adapter: Brass, pipe thread to 3/4-inch garden hose thread, with hose cap nut.

- C. Welded Branch and Tap Connections: Forged steel weldolets and thredolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ANSI B16.11 may be used for drain, vent and gage connections.

## 2.4 FITTINGS

- A. Copper Tubing:
  - 1. Solder Joint: Wrought copper, ANSI B16.22.
    - a. Solder for Drain Piping: 95-5 tin-antimony, ASTM B 32 (95TA).
    - b. Solder for Refrigerant Piping: Silver brazing alloy.
- B. Bronze Flanges and Flanged Fittings: ANSI B16.24.

## 2.5 DIELECTRIC FITTINGS

- A. Provide where copper and ferrous metal are joined.
  - 1. 2 Inch and Less: Threaded dielectric union.
  - 2. 2-1/2 Inch and Larger: Flange union with dielectric gasket and bolt sleeves.

## 2.6 THREADED JOINTS

- A. Pipe Thread: ANSI B2.1.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

## 2.7 VALVES

- A. Valves shall be Stockham, Milwaukee, Nibco, or Victaulic. All valves shall be suitable for 125 psi working pressure unless noted otherwise. Valves shall have threaded or grooved connections, except where flanges are specified they shall have flanged connections or where installed in hard drawn copper lines they may have sweat connections.
- B. Service Valves:
  - 1. 2-1/2 Inch and Smaller:
    - a. Gate valve: ASTM B-62 bronze body and solid wedge disc, rising stem MSS SP-80, Class 125.
    - b. Ball valve: ASTM B-584 Alloy 844 bronze body and stainless steel ball with teflon seats, conventional port, and blowout proof stems MSS SP-110, 150 PSI/600 PSI non-shock. Provide extended stem per application.
  - 2. 3 Inch and Larger:
    - a. Water service: ASTM A-536 ductile iron body butterfly, ASTM B-148 alloy 954/955 disc, EPDM seats, Class 200, locking-type manual lever.

- C. Globe Valves:
1. 2-Inch and Smaller: ASTM B-62 bronze body and disc, MSS SP-80, Class 125.
  2. 2-1/2 Inch and Larger: Similar to above, but ASTM A-126 flanged cast iron body, with bronze trim, bolt bonnet, OS & Y, renewable seat and disc.
- D. Check valves in sizes up to and including 2 inch shall be all bronze, swing type, with regrinding disc capable of being reground without removing the valve body from the line. Sizes 2-1/2 inch and larger shall be iron body, bronze-trimmed, regrinding seat, swing type, for water service.
- E. Balancing Cocks: Combination balancing and shut-off valves shall incorporate a position indicator and memory stop or locking device so the valve can be closed without disturbing the setting, and be returned to the balanced position without further adjustment.
1. 4-Inch and Larger: Butterfly valves or plug valves.
  2. 3-Inch and Smaller: Resilient faced eccentric plug or lubricated plug type, iron or steel body, bronze plug and bearings, wrench operated, rated 175 psig at 200 Deg. F.
- F. Triple-Duty Valve: ITT Bell and Gossett triple duty valve designed to perform the functions of a non-slam check valve, throttling valve, shut-off valve, calibrated balancing valve and system flow meter. The valve shall be of heavy-duty cast iron construction with standard 125 psig ANSI flanged connections, and rated for a maximum working pressure of 175 psig at 250 degrees F. The valve shall be fitted with a bronze seat, replaceable bronze disc, stainless steel stem and chatter-preventing spring. The valve design shall permit repacking under full system pressure. Each valve shall be equipped with brass readout valves with integral check valve for taking differential pressure readings across the orifice to accurately balance the system to specified design conditions.

## 2.8 STRAINERS

- A. Mueller Steam Specialty Co. No. 351 Y type.
1. Water Services: Rated 125 psig saturated steam at 450 Deg. F.
    - a. 2-1/2 Inch and Larger: Flanged, iron body, basket type (No. 165).
    - b. 2-Inch and Smaller: Bronze, threaded ends, Y type (No. 351).
  2. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
    - a. Steam Service: 0.045-inch diameter perforations.
    - b. Water Service:
      - (1) 2-1/2 Inch and Larger: 1/16-inch diameter perforations.
      - (2) 2 Inch and Smaller: 1/32-inch diameter perforations.
- B. Provide blow off outlet with pipe nipple and gate valve.

## 2.9 FLEXIBLE CONNECTORS FOR WATER SERVICE

- A. Flexible pipe joints shall be Flexonics Model PCS, stainless steel braided hose, pipe line size, flanged, minimum 125 psi working pressure at 250 degrees F.

#### 2.10 EXPANSION JOINTS

- A. Expansion joints shall be Flexonic internally guided, corrugated bellows, expansion compensator, Type HB, 2" minimum stroke, suitable for (steam) (hot water) service. Grooved pipe couplings and expansion compensators shall provide for expansion in grooved piping systems.
- B. Expansion joints shall be Kelflex GTI-M-311 (or equal) dual or single internally guided, corrugated bellows, expansion compensator, 2" minimum stroke, suitable for hot water service. Grooved pipe couplings and expansion compensators shall provide for expansion in grooved piping systems. Provide necessary pipe alignment guides as required for expansion joint installation.

#### 2.11 FLEXIBLE CONNECTORS FOR WATER SERVICE

- A. Flexible pipe joints shall be Flexonics Model PCS, stainless steel braided hose, pipe line size, flanged, minimum 125 psi working pressure at 250 Deg. F.

#### 2.12 HYDRONIC SYSTEM COMPONENTS

- A. Tangential Air Separators: Bell and Gossett "Rolairtrol", ASME Pressure Vessel Code construction for 125 psig working pressure, flanged tangential inlet and outlet connection, internal perforated stainless steel air collector tube designed to direct released air into expansion tank, bottom blowdown connection.
- B. Closed Expansion (Compression) Tanks: Bell and Gossett, ASME Pressure Vessel Code construction for 125 psig working pressure, rustproof coated. Provide gage glass, with protection guard, and angle valves with tapped openings for drain (bottom) and plugged vent (top).

1. Horizontal Tank: Provide cradle supports and following accessories:

- a. Air Control Tank Fittings: Provide in each expansion tank Bell and Gossett No. ATF or ATFL "Airtrol" tank fitting to facilitate air transfer from air separator, or purger, into tank while restricting gravity circulation. Fitting shall include an integral or separate air vent tube, cut to length of about 2/3 of tank diameter, to allow venting air from the tank when establishing the initial water level in the tank.
  - b. Tank Drainer-Air Charger: Bell and Gossett No. DT-2 "Drain-O-Tank" air charger shall incorporate a vent tube, cut to above 2/3 of tank diameter, and drain valve with hose connection draining and recharging with air.
  - c. Boiler Fitting: Bell and Gossett Model ABF or AFBF as applicable, top or side discharge as required.
- C. Fill valves shall be Watts No. N256 complete with strainer and check valve. Valve shall be adjustable 10 to 25 psi and shall be factory set at 15 psi. Provide full size manual bypass with cutoffs around fill valve for fast fill and purging.



- D. Fill valves shall be Watts No. U5B complete with strainer. Valve shall be adjustable 25 to 75 psi and shall be factory set at 50 psi. Provide full size manual bypass with cutoffs around fill valve for fast fill and purging.
- E. Regulating relief valves shall be adjustable setting type, bronze body, modulating action relief valve as manufactured by Klipfel, Illinois, or Consolidated. Size to relieve 50% of pump capacity. Set to relieve when system head is 5 foot w.g. above specified system pump head.
- F. Air Vents:
  - 1. Automatic air vents shall be Hoffman No. 79, suitable for 75 psi service, and shall provide venting operation under all conditions. Exhaust port from each vent shall be extended with a concealed 1/4" copper tubing to floor of equipment rooms, to a drain, or to 6" above grade at building exterior.
  - 2. Manual air vents shall be chromium-plated brass 1/8" NPT coin-operated type. Provide extension tube if required to maintain access to vent operator.
- G. Drains: Drains shall be accessible with 3/4" hose-end drain valve unless indicated otherwise.

#### 2.13 WATER FLOW MEASURING DEVICES

- A. Circuit setters shall be Bell and Gossett bronze balance valve with provisions for connecting a portable differential pressure meter. Meter connections shall have built-in check valves. An integral pointer shall register degree of valve opening. Each balance valve shall be constructed for 125 lbs. working pressure at 250 Deg. F. Furnish one differential meter Model RO-5 complete with meter, cutoffs, piping, fitting, and hose. The valve pressure drop and the setting shall determine the actual system flow rate.
- B. Automatic Flow Control Valves shall be Griswold, Autoflow, Hays or equal and shall be provided at all water source heat pump units. Valves shall be automatic pressure compensating type and factory set to provide specified flow rates within five (5) percent regardless of system pressure. Valves shall be selected to provide specified flow rates with a minimum pressure differential of 2 psig and maximum pressure drop of 10 feet of water. Where system differential exceeds 32 psig, valves shall be selected for a range of 4-57 psig. Valve body shall be suitable for use with piping system and internal working parts shall be stainless steel, nickel plated brass or elastomeric diaphragm. All valves shall be provided with union and pressure-temperature test ports suitable for connecting differential pressure measuring devices. All valves shall be wye configuration for removal of controlling element without removing valve from piping. Each valve shall be identified as to direction of flow and flow rate. One differential pressure meter shall be provided complete with dual hose kit, valves, flow conversion chart and carrying case. Meter and accessories shall be turned over to the Owner upon final acceptance of the project.

#### 2.14 GAGES, PRESSURE AND COMPOUND

- A. Pressure gauges shall be Ashcroft bourdon tube, general service type suitable for 125 psi service. Gauges shall not be less than 4" dial type with aluminum case and gauge cock. Gauges shall be graduated in feet of water and psi.
- B. Range of Gages: Provide range equal to at least 150 percent of normal operating range.

2.15 THERMOMETERS

- A. Weksler Instruments Type AA, Fed. Spec. GG-T-321, non-mercury fluid filled type, blue column, clear plastic window, with 6-inch brass stem, straight, adjustable angle as required for each in reading.
- B. Scale: Not less than nine inches, range as described below, two degree graduations.
- C. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- D. Scale ranges may be slightly greater than shown to meet manufacturer's standard.

2.16 UNDERGROUND PIPING

- A. Heated water lines in covered pipe trench: Pipe and insulation shall be Energy Task Force, Rovanco or Ricwel insulated piping system complete with pipe, insulation, outer jacket, and matching fittings for a complete installation. Pipe shall be Type L Copper, ASTM B-88. Pipe shall be factory insulated with polyurethane closed cell foam completely filling the annular space between the service pipe and the outer jacket. The insulation shall be 1.68 inches thick having a K-Factor of 0.15, 2.0 PCF density, 90-95% closed cell conforming to mil spec – 1-24172 and ASTM-C-591. The outer jacket shall be watertight, high impact seamless polyvinylchloride (PVC) class 12454 B, conforming to ASTM 1784 Type 1, Grade 1. Provide pipe anchors as indicated and as required to control pipe expansion. Provide compressible material at expansion legs. Insulated piping system shall be installed in strict accordance to the manufacturer's recommendations.
- B. Manufacturer's Field Installation Instruction: On completion of the installation, the Contractor shall deliver to the Owner a certificate from the manufacturer stating that the installation has been made in accordance with the manufacturer's recommendations.

2.17 END SUCTION WATER PUMP

- A. General - End suction water pump shall operate at not over 1750 rpm and shall be suitable for pumping water at 210°F.
- B. End suction water pump shall be Bell & Gossett base-mounted pump Series 1510 or equal with Class 30 cast iron volute with integrally-cast support, cast bronze impeller, enclosed type, dynamically balanced, mechanical shaft seals with carbon seal ring for continuous operation @ 225.0 Deg. F, minimum working pressure of 175 psi. Casings shall have gauge ports at nozzles and vent and drain ports at top and bottom of casing. Housing assembly shall have replaceable heavy-duty regreasable ball bearings. Pump and motor shall be mounted on a common base. Base ends, with securely welded cross members and fully open grouting area. A flexible-type coupler shall connect the pump and U.L. Listed motor. The coupler shall be complete with safety guard meeting compliance with ANSI B15.1, Section 8 and OSHA 1910.219. Contractor to level and grout each unit according to manufacturer's instructions. The motor shall meet NEMA specifications and shall be the size and voltage called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by Contractor after installation. Each pump shall be factory tested, cleaned, and painted with high-grade machinery enamel. Unit shall be checked by the Contractor and regulated for proper differential pressure, voltage, and amperage draw. Data shall be noted on a permanent tag and fastened to the pump.

- C. Submit the manufacturer's certified characteristics performance curve for the impeller size to be furnished. The operating point on the characteristic performance curve shall be to the left (shut-off side) of the curve. The pump motor shall be non-overloading at any point on the head-capacity curve.

## 2.18 SUCTION DIFFUSER

- A. Provide Bell & Gossett Model (NPT) (FLG) suction diffuser for each base-mounted pump. (Flange connections for field piping shall be drilled and faced per 150# ANSI Standards.) Units shall consist of angle type body with straightening vanes and combination Diffuser-Strainer-Orifice Cylinder with maximum 3/16" diameter openings for pump protection. Diffuser shall be equipped with a disposable, bronze, 16 fine mesh strainer which shall be removed after system start-up. Orifice cylinder shall be designed to withstand pressure differential equal to pump shutoff head and shall have a free area equal to five times cross section area of pump suction opening. Straightening vanes shall extend the full length of the orifice cylinder and shall be replaceable. Unit shall be provided with adjustable support foot to help carry weight of suction piping. Maximum working pressure shall be 175 psi @ maximum operating temperature of 250°F. The unit pressure drop shall not exceed 1.0 psi for design pump gpm.

## PART 3 - EXECUTION

### 3.1 PIPING INSTALLATION

- A. General:
  - 1. The drawings show the general arrangement of pipe and equipment but do not show all fittings and offsets that may be necessary.
  - 2. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
  - 3. Support piping securely. Refer to Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC). Suspended horizontal piping shall be supported by adjustable wrought steel clevis hangers, except that straight runs of piping with 40 feet or more between anchor and expansion device shall be supported on roller type hangers or supports. Protection saddle, welded to pipe, shall be provided at each roller support. All supports shall be attached to the building structure and shall in no way be attached to the supports or other equipment, piping, or ductwork. Where supports bear on copper pipe, they shall be copper plated. Chain, strap, or other makeshift devices will not be permitted as hangers or supports. Maximum pipe support spacing shall be in accordance with Table 1 – MAXIMUM PIPING SUPPORT SPACING, except where grooved couplings are used, no pipe length shall be left unsupported between any two grooved couplings:

**Table 1 - Maximum Piping Support Spacing**

PIPING MATERIAL	MAXIMUM HORIZONTAL SPACING (feet)	MAXIMUM VERTICAL SPACING (feet)
ABS Pipe	4	10 <sup>c</sup>
Aluminum Pipe and Tubing	10	15
Brass Pipe	10	10
Brass Tubing, 1¼-inch Diameter & Smaller	6	10
Brass Tubing, 1½-inch Diameter & Larger	10	10
Cast-Iron Pipe <sup>b</sup>	5	15
Copper or Copper-Alloy Pipe	12	10
Copper or Copper-Alloy Tubing, 1¼-inch Diameter and Smaller	6	10
Copper or Copper-Alloy Tubing, 1½-inch Diameter & Larger	10	10
CPVC Pipe or Tubing, 1-inch & Smaller	3	10 <sup>c</sup>
CPVC Pipe or Tubing, 1¼-inch & Larger	4	10 <sup>c</sup>
Lead Pipe	Continuous	4
PB Pipe or Tubing	2-2/3 (32 inches)	4
PEX Tubing	2-2/3 (32 inches)	10 <sup>c</sup>
Polypropylene (PP) Pipe or Tubing, 1-inch or Smaller	2-2/3 (32 inches)	10 <sup>c</sup>
Polypropylene (PP) Pipe or Tubing, 1¼-inch or Larger	4	10 <sup>c</sup>
PVC Pipe	4	10 <sup>c</sup>
Steel Tubing	8	10
Steel Pipe	12	15
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm a. See Section 301.18. b. The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed. c. Mid-story guide.		

4. Supports on chilled water and condensate drain lines shall be provided with a 12" long section of hydrous calcium silicate, which shall have joints sealed and covered with a vapor barrier jacket. Hanger rods shall be 3/8" diameter size for pipes up through 2", 1/2" diameter size for 1-1/2" through 3", 5/8" diameter for pipes 4" through 5", and 7/8" diameter size for 6" through 12". Pipe hanger rods shall be attached to the top chord only on steel joists and beams by joist or beam clamps without welding. Welding of support rods and connection at any place other than the top chord will not be permitted unless written approval is granted by the Architect.
5. Install piping generally parallel to walls and column centerlines, unless shown otherwise on the drawings. Space piping, including insulation, to provide one inch minimum clearance between adjacent piping or other surface. Pipe shall be installed to permit free expansion and contraction without damage to joints or hangers. Slope piping down in the direction of flow not less than one inch in 40 feet. Provide eccentric reducers to keep bottom of sloped piping flat. All high points in water lines shall be provided with manual-air vents, all low points with drains. Condensate drain lines shall slope 1/8" per foot in direction of flow.
6. Anchors for pipe shall be provided as indicated or as required at the job site to localize expansion and contraction of pipe. Anchors shall consist of heavy steel or brass collars bolted or welded to the pipe and rigidly connected to the building structure unless indicated otherwise. Anchor braces shall not be attached in places where they will damage or injure the structure during installation or by the weight or expansion force of the pipe line after installation.

## Renovate First Floor of Dietrick Hall and Plaza

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7. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Control valves usually require reducers to connect to pipe sizes shown on the drawings. Isolation service valves shall be installed on each side of major piece of equipment such as a pump, boiler, chiller, heating coil, cooling coil and other similar items, and at any other points indicated or required for draining, isolation or sectionalizing purposes. Control valves shall be installed in accordance with control manufacturer's recommendations.
8. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line takeoffs with 3-elbow swing joints where noted on the drawings.
9. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tee, which is two return lines entering opposite ends of a tee and exiting out the common side or two supply lines exiting opposite ends of a tee and entering the common side.
10. Connect piping to equipment as shown on the drawings. Piping connections to equipment shall be provided with unions or flanges. (Banked water coils shall be piped in reverse return arrangement.) (Steam coils shall be trapped individually.) (Vacuum breaker shall be provided at steam supply connection to each steam coil or steam bundle.) A straight spool piece equal in length to impeller diameter shall be provided at suction connection to each pump. Install components furnished by others such as:
  - a. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
  - b. Thermometer Wells: In pipes 2-1/2 inches and smaller, increase the pipe size to provide free area equal to the upstream pipe area.

### B. Pipe Joints:

1. Sweated: Copper tubing shall be cut square, ends reamed, and all filings and dust wiped from interior of pipe. Joints shall be soldered with solder drawn through the full fitting length. Excess solder shall be wiped from joint before solder hardens. Solder shall be 95/5 composition; 50/50 will not be allowed.
2. Threaded: Threaded joints shall be made with tapered threads properly cut. Joints shall be made tight with a stiff mixture of litharge and glycerin or other approved thread joint compound applied with a brush to the male threads only. Not more than three threads shall show after the joint is made up.
3. Grooved: Pipe coupling joints shall be assembled according to manufacturer's specifications. Pipe shall be square cut and grooved in accordance to manufacturer's specifications. Gaskets shall be verified as suitable for the intended service and shall be coated on the lips and back with a thin uniform coat of lubricant. The coupling housing shall be assembled over the gasket and shall engage both grooves. The nuts shall be uniformly tightened until the housing pads are firmly together metal to metal.
4. Welded: Joints shall be fusion-welded by qualified welders in accordance with ANSI B31.10, unless otherwise required. Changes in direction of piping shall be made with fittings only. Mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Saddle-type welding outlets may be used for equipment take-offs from the mains.
5. Flanges and Unions: Fittings shall be faced true and made square and tight. Unions shall be 125 psi service, bronze seat type. Flanges shall be ANSI Standard 125 psi service with 1/16" thick red rubber gaskets. Unions and flange joints shall be provided on each side of each valve 2-1/2" or larger and in each line immediately preceding the connection

to each major piece of equipment such as a (pump), (converter), (boiler), (chiller), (heating coil), (cooling coil) and other similar items.

6. Dielectric fittings such as couplings, unions, or flanges, shall be installed to isolate pipes of non-ferrous metal where connection is made to ferrous metal. Isolation shall be accomplished by non-metallic, unthreaded sleeves or gaskets or a combination of both. Fittings shall be so designed that the installing tools cannot come in contact with the insulating material. Materials shall withstand pressure and temperature as required.

C. Leak Testing:

1. Inspect all joints and connections for leaks and workmanship and make corrections as necessary.
2. A hydrostatic test at 1.5 times design pressure for 4 hours. Factory tested equipment (converters, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

### 3.2 FLUSHING AND CLEANING PIPING SYSTEMS

A. Water Piping: Clean systems as recommended by the suppliers of the boiler water treatment chemicals specified in this section.

1. Initial Flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Bypass factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 6 feet per second, if possible. Connect deadend supply and return heads as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary or permanent piping and Contractor's booster pumps. Flush until clean.
2. Cleaning: Using products recommended by the suppliers of the boiler water treatment chemicals specified in this section, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by initial flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where deadend debris accumulation cannot occur. Sectionalize system as possible, to circulate at velocities not less than 6 feet per second. Circulate each section for not less than 4 hours. Blowdown all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
3. Final Flushing: Return system to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all deadends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush not less than one hour.

### 3.3 WATER TREATMENT

- A. The Contractor shall provide services of a boiler water treatment firm to test the raw water at the site and provide chemicals necessary to maintain the following characteristics of water in the boiler for a period of one year:

Hardness:	0.00
Iron:	0.00
Total Dissolved Solids:	1500-1750 ppm (as Ca CO <sub>3</sub> )
Silica:	60 ppm or less
pH:	10.4 or above

- B. Close and fill system as soon as possible after final flushing to minimize corrosion.
- C. Charge system with chemicals.

### 3.4 PUMPS

- A. Provide concrete pads for all pumps.
- B. Provide vibration isolation as specified in Section 23 05 48, VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.
- C. After all piping is properly installed and connected, verify final pump shaft alignment is within tolerances as recommended by the pump manufacturer during both hot and cold temperature operation.

### 3.5 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Perform all tests and make reports in accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

END OF SECTION 232000





## SECTION 233000 - HVAC AIR DISTRIBUTION

### PART 1 - GENERAL

#### 1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) are hereby made a part of this section, and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

#### 1.2 DESCRIPTION OF WORK

- A. Ductwork and accessories for HVAC including the following.
  - 1. Supply air, return air, and general exhaust systems
- B. Installation of control dampers and smoke detectors referred to in other Division 23 sections.
- C. Definitions:
  - 1. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
  - 2. SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Inc. Publication entitled HVAC Duct Construction Standards Metal and Flexible, latest recognized edition.
  - 3. Duct Pressure Classifications:
    - a. General Duct System: 1 inch water column pressure class unless noted otherwise.
    - b. Variable Volume Duct System: 2-inch water column pressure classification for duct upstream of the variable volume dampers.
  - 4. Exposed Duct: Exposed to view in a finished room.
  - 5. Outside Duct: Exposed to view beyond the exterior side of walls or above the roof.

#### 1.3 RELATED WORK

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- C. Section 230700, HVAC INSULATION.
- D. Section 230900, INSTRUMENTATION AND CONTROL FOR HVAC.
- E. Section 238200, CONVECTION HEATING AND COOLING UNITS.

#### 1.4 QUALITY ASSURANCE

- A. Fire Safety Code: Comply with NFPA 90A.
- B. Duct System Construction: SMACNA standards are the minimum acceptable quality.
- C. Duct accessories exposed to the air stream, such as dampers of all types and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

#### 1.5 SUBMITTALS

- A. In accordance with Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
  - 1. Manufacturer's Literature and Data:
    - a. Volume, Motorized, and Backdraft Dampers
    - b. Prefabricated Metal Ductwork: Manufacturer's details for round and oval duct and fittings.
    - c. Duct Access Doors, Panels, and Sections
    - d. Flexible ducts, connections fittings and clamps, with manufacturer's installation instructions.
    - e. Flexible connections
    - f. Air Outlets and Inlets
    - g. Fire dampers
    - h. Smoke dampers
    - i. Fire/Smoke Dampers

### PART 2 - PRODUCTS

#### 2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A 653, coating G90.
- B. All ductwork exposed to view in finished spaces shall have paint grip to accept field painting.
- C. Joint Sealing: Refer to SMACNA Table 1-2 for requirements. In addition all general duct systems shall meet Seal Class C and shall comply with South Coast Air Quality Management District (SCAQMD) Rules 1113, 1168 and Green Seal Standards GS-11 and GS03 for VOC limits.
  - 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork. Use products as recommended by the manufacturer for each applicable system pressure. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

2. Tape: The use of pressure sensitive tape as a general duct sealant is not acceptable.
3. A few of the many satisfactory sealants are as follows:
  - a. Moore Tuff-Bond, #29 for low pressure, #12 for high pressure.
  - b. Minnesota Mining and Manufacturing Company EC 800.
  - c. Hardcast R 6350 tape and activator/adhesive.
  - d. United Sheet Metal R-5966 (N), Listing #1.
  - e. Borden Arabol E-3806 lagging adhesive plus 6 ounce canvas.
4. Gaskets in Flanged Joints: Soft neoprene.

D. Approved factory made joints such as DUCTMATE SYSTEM may be used.

E. The interior surfaces of all new ductwork shall be coated with an anti-microbial treatment. The following manufacturers are acceptable. Approved proposed equals will be considered but must be specifically approved the University. Treatment can be either field or factory applied.

1. Anti-microbial Paint – PorterSept Product #3830 by Porter Paint Co.
2. AgION anti-microbial compound treatment for metal duct and equipment, blue coating. Process as provided by Lindab, Inc.
3. Avron 46 anti-microbial coating by Semco, Inc.

## 2.2 METAL DUCTS

A. Gages, Reinforcement, Joints, Seams, Sealing, Fittings, Supports, and Other Details per SMACNA: Construct ducts not shown otherwise for 2 inches wg static pressure rating.

B. Sealing: All supply and return ductwork and plenums, regardless of pressure class, shall be sealed to SMACNA Seal Class A. Exhaust ductwork and plenums of pressure class greater than 2" shall be sealed to Seal Class A. All other exhaust ductwork and plenums shall be sealed to Seal Class C.

C. Kitchen Hood/Dishwasher Hood Exhaust Ducts: 18 gage stainless steel, liquid tight welded construction. Mechanical fasteners shall not be used for assembly or support where such fasteners could penetrate the duct walls. Ducts shall run continuous from the hood connection to the exhaust fan connection above the roof. Access doors shall be provided in the side of each horizontal section of duct for cleaning purposes. Access doors shall be a minimum of 12 inches or shall be the full width of the duct and shall be located at a maximum spacing of 20 feet.

D. Volume Dampers: Single louver type and multi-louver type as detailed in SMACNA. Maximum blade louver width shall be 8 inch. Volume dampers exceeding 8 inch shall be multi-louver type. Dampers shall be a minimum two gauges heavier than duct in which installed.

1. Manual dampers shall be opposed blade construction for modulating service. Manual operator mechanism shall be locking-type quadrant operator as manufactured by Young Regulator Company or equal. End of damper rod on each damper shall be grooved to show damper position. Quadrant operators shall be installed on 1-1/2" high 4-bend galvanized steel bracket allowing duct insulation to be extended and sealed under the quadrant operator. (Where dampers occur behind or above finished portions of the building, operating rods shall be extended to 301 or 315 regulators installed flush with the finished surface.)

2. Motorized dampers shall be opposed blade construction for modulating service and parallel blade construction for two-position service. Motorized dampers shall be constructed with brass bearings, channel iron frame, interlocking blades and air-tight felt seals. Motor operators for dampers are specified in Section 23 09 00, INSTRUMENTATION AND CONTROL FOR HVAC.
- E. Turning Vanes: Provide in all square elbows even though not shown on the drawings. Turning vanes shall be factory fabricated. Vanes shall be hollow, double thickness in all ducts 18" or larger.
- F. Air Deflectors: Factory fabricated for air diversion and volume control with operator as required for location in an accessible position. Adjustable deflectors shall be Young Air Extractor Model 890 with worm gear operator when behind grilles, with 301 operator when above plaster ceilings, and with 433 operator when it is accessible.
- G. Plenums and Casings (Site Fabricated Units): Construct of galvanized steel panels joined by standing seams on outside of casing. Rivet or bolt all seams and joints on approximately 6" centers and seal with sealant. Reinforce with steel angles and provide diagonal bracing. Access doors shall be 36" x 18" with frame welded to plenum, three brass hinges and three brass tension fasteners operable from either side of door.

### 2.3 PREFABRICATED METAL DUCTWORK

- A. Gages, joints, seams, reinforcement, fittings, sealing, supports and other details for rectangular, round and oval duct shall be in accordance with SMACNA.
- B. Sealing: Seal Class A (4 inch wg static), Class B (3 inch wg static) or Class C (up to 2 inch wg static) in accordance with SMACNA Table 1-2 requirements.
- C. Ducts and Casings: Submit details of proposed joints/sealing system. Unless shown otherwise, construct supply duct to 2 inches wg static pressure. Provide bolted construction and tie-rod reinforcement where required.
- D. Round and Oval Ducts:
  1. Spiral duct and all fittings shall be Semco, MKT or United McGill spiral lock-seam duct.
  2. Elbows: Diameters 3 through 8 inches shall be two sections die stamped, all others shall be gored construction with all seams continuously welded. Coat galvanized areas of fittings damaged by welding with corrosion-resistant aluminum paint or galvanized repair compound.
  3. Provide bellmouth, conical tees, laterals, reducers, and other low loss fittings as shown in SMACNA Standards.
  4. Double wall insulated duct: Spiral double wall insulated pipe with matching fittings constructed from galvanized steel meeting ASTM-A527 and SMACNA. Outer shell for straight spiral pipe shall be 24-gauge for duct diameters through 24 inch, 22 gauge for duct diameters 25 inch through 34 inch, and 20 gauge for duct diameters 35 inch through 48 inch. Outer shell for fittings shall be 22 gauge for duct diameters 24 inch, and 20 gauge for duct diameters up to 48 inch. Insulation between pipe walls shall be 1-inch thick fiberglass with a thermal conductivity of 0.26 BTU/Hr./Sq. Ft./Deg. F. Inner shell shall be metal solid liner. Spiral pipe liner shall be 28 gauge. Fittings liner shall be solid metal type of 26 gauge for diameters through 34 inch and 24 gauge for diameters 35 inch through 48 inch diameter. Branch takeoffs shall be bell mouth type. Elbows shall be five-

section type. Transitions shall be conical type. Duct connectors and fittings shall be casketed air-tight seal. Ductwork shall be provided and handled for "exposed" installation. Duct finish shall be A-60 annealed, paintable steel. Provide duct hangers, dampers, and appurtenances for a complete installation. All "exposed" ductwork shall be installed in a neat finished workmanlike manner and without visible duct sealant. Provide dimensional duct layout with shop drawing. Coordinate duct takeoffs with roof truss system.

- E. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the Architect/Engineer.
- F. Duct Hangers and Supports: Refer to SMACNA. Avoid use of trapeze hangers for round duct.

#### 2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

- A. Provide access doors in accordance with NFPA 90A, sized and located for maintenance work, upstream where possible, in the following locations:
  - 1. Each automatic control damper.
  - 2. Each duct mounted smoke detector.
  - 3. Each fire damper and smoke damper.
  - 4. Each apparatus requiring service or inspection.
  - 5. Each kitchen hood exhaust duct elbow and six foot intervals of horizontal grease duct.
- B. Openings shall be 15" x 18" unless noted otherwise, except where size of duct will not accommodate this size, they shall be made as large as practical. Access doors shall be of rigid type and shall be provided with gasket to make air tight. Door shall be provided with galvanized hinges having bronze pins and two approved brass fasteners. Access doors in insulated ducts shall be of the insulated type. Doors shall swing so that fan pressure or suction and direction of air flow holds the door closed.
  - 1. For Rectangular Ducts: Refer to SMACNA and provide lock type 2 (door latch, not sash lock).
  - 2. For Round Ducts: Access sections shall be not less than 20 gage housing welded or riveted to a duct section.

#### 2.5 FLEXIBLE AIR DUCTS

- A. General: Factory fabricated, complying with NFPA 90A for connectors up to 6 feet maximum length and not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier as defined in Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC). Provide approximate lengths indicated on the drawings. Provide insulated, acoustical air duct connectors in supply air duct systems and elsewhere as shown.
- B. Flexible ducts shall be acoustically insulated type as manufactured by Thermaflex or Flexmaster. Duct shall be fabricated with an acoustically transparent CPE inner film, 1" fiberglass insulation, and reinforced metalized vapor barrier. Vapor barrier permeance shall be .05 per ASTM E96, Procedure A. The rated positive pressure shall be 10" water gage and the recommended operating pressure for 90 degree bends shall be 6" water gage for 12" diameter duct. The minimum 'R' value shall be minimum 4.2, except in unconditioned attic type spaces

the minimum 'R' value shall be 5.5. Entire assembly shall have maximum Flame-Spread rating of 25, a Smoke Developed Rating less than 50, and shall meet all NFPA 90A requirements. Connections between flexible duct and ductwork fittings or diffusers shall be made with draw bands and sealed with an approved pressure-sensitive tape. Flexible duct shall be UL 181 listed, ETL Class1.

Duct Insertion Loss, dB

Octave Band Frequency, Hz	2 125	3 250	4 500	5 1000	6 2000
6 inch duct	7	19	34	37	38
8 inch duct	8	13	29	35	36
12 inch duct	20	26	27	33	26

- C. All round duct take-offs shall be made with SPIN-IN fittings or pre-manufactured tap fittings with flanged low-loss boot and round connection collar. Units shall have a balancing damper and a factory-installed spring-loaded retractable bearing and a positive locking wing nut for easy readjustment. Provide 2" insulation stand-off for balancing damper handle.
- D. Connection between high velocity duct and variable air volume boxes shall be made with high pressure flexible duct runouts unless shown otherwise. Insulation shall be a nominal 1-inch by 1 lb/cf fiberglass sheathed in a seamless vapor barrier jacket. The duct shall be rated for 15 inches of water pressure. Connection between flexible duct and ductwork fittings or variable air volume boxes shall be by manufacturer's recommendations. The duct shall comply with the latest NFPA Bulletin 90A and be listed as Class 1 connector, UL Standard 181.

## 2.6 FLEXIBLE CONNECTIONS

- A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 29 ounce neoprene coated fiberglass fabric approximately six inches wide. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws two inches on center. Fabric shall not be stressed other than by air pressure. Allow at least one inch slack to ensure that no vibration is transmitted.

## 2.7 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum two-inch length for insulated duct, and a minimum one-inch length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil and cooling coil.

## 2.8 AIR OUTLETS AND INLETS

- A. Materials:
  1. Steel or aluminum as indicated. Provide manufacturer's standard gasket.

2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless steel. Provide concealed method of fastening where available.

B. Performance Test Data: In accordance with Air Diffusion Council Code 1062R4.

C. Finish: White baked enamel for ceiling mounted units. Wall-mounted units shall be primed.

D. Air Supply Outlets and Inlets: Manufacturer shall be Price, Titus, Tuttle and Bailey, or Metal-Aire. Price model numbers are listed.

1. Square ceiling supply diffusers shall be Model SPD 24" x 24" square plaque diffusers for lay-in mount for inverted T-bar ceiling without panel extensions. Face panel shall have smooth edges and rounded corners to blend with back cone. Diffuser shall deliver 360 degree radial horizontal air pattern. Provide opposed blade manual damper and equalizing deflectors. Construction shall be steel with mitered blade joints.

2. Supply registers shall be Type 520/D/F/S/A steel double deflection and shall have free area of not less than 75%. Register dampers shall be aluminum opposed blade type, face operated. Sponge rubber gasket shall be provided on frame.

3. Return registers and grilles shall be Model 530/D/F/L/A fixed blade aluminum construction with 45 degree deflecting vanes on 3/4" centers. Units shall have free area not less than 75%. Register dampers shall be aluminum opposed-blade face-operated type. Sponge rubber gasket shall be provided on frame. Wall-mounted units shall be provided with horizontal face blades.

4. Linear floor grilles shall be Model LFG-HC with core 25C supply grilles. The grille face shall have a 1" extruded aluminum border and an overall dimension suitable to match and coordinated with the concrete trenches in the vestibules and the mounting detail on sheet M301. The grille face and border shall be capable of a straight drop installation. The grille shall be fastened using screw mounting/spring-clip mounting. Grilles shall have a fixed 0° blades spaced 7/16" on center. The outlet core shall have extruded aluminum receiving bar. Blades shall run parallel to the long dimension of the grille. The grille border shall be heavy-duty extruded aluminum construction with precise factory mitered corners and reinforcing support bars for extra support for the core receiving bar. The support and receiving bars shall not exceed 8" on center. The core shall be held into the border with removable core clips allowing the removal of the core without special tools. The grille finish shall be coordinated with the ARCHITECT. The LFG shall be constructed with the HC configuration.

## 2.9 BIPOLAR IONIZATION GENERATOR

A. Bipolar ionization generator shall be Global Plasma Solutions GPS-FC48-AC or approved equal designed for fan inlet or inside wall HVAC system mounting applications. Unit shall be self-cleaning type, universal voltage input from 24VAC to 260VAC with integral display, programmable cleaning cycle, integral alarm contacts (250VAC/1A), replaceable carbon fiber brush emitters, magnets, mounting brackets, and all hardware and accessories required for installation.

B. Unit power shall be 12 VA, 60 Hz. Airflow capacity for each unit shall be 4,800 CFM. Unit shall be UL and cUL listed.

## 2.10 ION DETECTOR

- A. The Ion Detector shall be Global Plasma Solutions GPS-IMEASURE or approved equal. Unit shall be auto-calibration, auto-zero, 2-10VDC output for 24 hour BMS monitoring, include watchdog time, bi-color LED, 0-10,000 ions/cc range, and suitable for duct and space mounting. Ion detector shall measure and monitor ionization levels in the air and communicate back to the Owner's BAS.
- B. Unit shall be suitable for operation in 0-90% humidity (non-condensing) and shall include UL94VO ABS enclosure.

## 2.11 FIRE DAMPERS

- A. General - Fire dampers shall be dynamic type. Dampers shall meet local codes and the standards of the National Fire Protection Association contained in Bulletin 90A. Dampers in ductwork shall be sized so that the free air space is not less than the connected duct free air space. (Damper installed behind grilles or registers shall be the same size as the grille or register with blades in the air stream.) Location shall be as shown on drawings or as required by local code. Dampers shall possess a 1-1/2 hour standard fire protection rating in accordance with NFPA No. 555.
- B. Material - The frame shall be constructed so as to be unaffected by corrosion or high heat. Mechanical parts shall have bronze non-corrosive pins. Vertical and horizontal dampers shall feature closure spring operation suitable for closure against the installed system air stream. When closed, the dampers shall be held closed by a catch arrangement. Blades installed in regular ductwork will not be accepted.
- C. Fuse Links - Fire curtains shall be arranged to close automatically and remain tightly closed upon the operation of an approved fusible link or other approved heat-actuated device, located where readily affected by an abnormal rise of temperature in the duct. Fusible links shall have a temperature rating approximately 50 Deg. F above the maximum temperature that would normally be encountered when the system is in operation or shut down.
- D. Access doors shall be provided in accordance with NFPA 90A. Suitable openings shall be provided to make fire dampers accessible for inspection and maintenance.

## 2.12 SMOKE DAMPERS

- A. General - Dampers shall meet local codes and the standards of the National Fire Protection Association contained in Bulletin 90A. Locations shall be as shown on the drawings.
- B. Performance - Each damper shall be classified by Underwriter's Laboratories as a leakage rated damper for use in smoke control systems under the latest version of UL 555S, and shall bear U.L. Label attesting to same. The leakage rating under UL 555S shall be Leakage Class II (10 CFM Sq. Ft. at 1" W.G.). As part of the U.L. qualification, dampers shall have demonstrated a capacity to operate under HVAC system operating conditions, with pressures of at least 4" W.G. in the closed position, and 2000 FPM air velocity in the open position. The dampers and their actuators shall be qualified under UL 555S to an elevated temperature of at least 250 Deg. F.
- C. Materials - Damper frames shall be a minimum of 16 gage galvanized steel formed into a structural hat channel shape with tapped corners for reinforcement. The blades shall be single skin 16 gage minimum galvanized with three longitudinal grooves for reinforcement. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Blade edge seals shall



be silicone rubber designed to withstand 450 Deg. F and jamb seal shall be silicone impregnated fiberglass with stainless steel flexible metal compression type cover. Appropriate electric (120V-1PH) actuators shall be furnished and installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity which meets all applicable UL 555S qualifications for both dampers and actuators. Factory supplied caulked sleeve shall be 20 gage. (.91) for dampers through 84" (2134) wide and 18 gage (1.21) above 84" (2134) wide. Damper and actuator assembly shall be factory cycled 10 times to assure operation. All wiring or piping material required to interconnect the actuator with detection and/or alarm or other systems shall be furnished by others as detailed elsewhere in the specification. Dampers shall be Ruskin Model SD36 or approved equal.

- D. Access holes - Suitable hand hole openings with tightly fitted covers shall be provided to make them accessible for inspection and maintenance.
- E. Operation - Damper motor shall de-energize to allow spring-loaded damper to close when smoke is detected by a space-mounted smoke detector. Smoke detectors will be provided under the Electrical Specifications.

#### 2.13 FIRE/SMOKE DAMPERS

- A. Fire/smoke dampers shall conform to the requirements of Underwriters' Laboratories standard for smoke dampers UL 555S and for fire dampers UL 555 for 1-1/2 hour rating. Operator shall be 120 VAC/60 Hz, normally closed type.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with provisions of Section 23 00 00, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), particularly regarding coordination with other trades.
- B. Fabricate and install ductwork and accessories in accordance with SMACNA Standards:
  - 1. Duct clearance and lengths shall be established from measurements taken at the job site before any ducts are fabricated. The Contractor will not be allowed any extra costs for ducts fabricated and then found not to fit into the space intended. Duct sizes on the drawings are actual sheet metal dimensions which shall be altered by the Contractor to other dimensions producing the same air handling characteristics where necessary to avoid interferences and clearance difficulties. Acoustically lined duct has been sized to include the lining.
  - 2. Fire damper openings shall be established from measurements taken at the job site before any fire damper is fabricated. The Contractor will not be allowed any extra costs for dampers fabricated and then found not to fit into the space intended. The Contractor shall coordinate clearances for locating the damper blades out of the air stream as required.
  - 3. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA. Weld sheet metal in accordance with SMACNA, Guidelines for Welding Sheet Metal. Repair damaged galvanized areas with galvanizing repair compound.
  - 4. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA.

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5. Construct casings and pipe penetrations in accordance with SMACNA. Design casing access doors to swing against air pressure so the pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA. Duct supports shall consist of not less than 1" x 16 ga. galvanized steel strap hangers spaced not over 8'-0" on center for ducts with up to 240" perimeter.
- D. Duct floor and wall openings - Rectangular and square ducts shall have openings 1" larger than the overall duct dimensions framed in place when the wall is constructed and 1/4" larger when floors are poured. Space between duct and structure shall be filled with duct insulation, except in fire partitions or floors they shall be packed tight with non-combustible fiber rope. Flanges constructed of 22-gauge galvanized sheet metal, not less than 3" wide, shall be installed at each opening in finished areas.
- E. Flexible Duct Installation: Continuous, single pieces not over fourteen feet long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with adhesive and clamps or screws as recommended by the duct manufacturer. Flexible ducts shall not penetrate any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hours.
- F. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- G. Control Damper Installation:
  1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
  2. Assemble multiple section dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
  3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
- H. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.
- I. Installation of Diffusers, Registers, and Grilles: Ducts shall be fastened securely to the building construction at each side of opening. Diffuser, register, or grille shall be securely fastened thereto, snug against the wall.
- J. Installation of Fire and Smoke Dampers and Fire/Smoke Dampers: Dampers shall be installed so as to provide the positive barrier to passage of air when in a closed position. Dampers shall be located and installed so that destruction of the duct on either side of the damper will not allow the damper to fall away from the opening to be protected. Dampers shall be located in the wall or ceiling, or as close thereto as possible, and securely fastened thereto. Where it is not possible to locate the damper directly adjacent to the wall or ceiling, it shall be located as close as possible and all ductwork between the damper and wall or ceiling shall be fireproofed with plaster or other approved methods to give a rating equal to the rating of the damper. Access doors in the duct and wall or ceiling where applicable shall be sized and located as required for inspection and maintenance of the damper. Damper installation shall be as recommended by

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the manufacturer for UL compliance and shall meet all requirements of NFPA Standard 90A. Dampers shall be installed with sufficient tension to prevent rattling or vibration. The installation of the dampers shall conform to the requirements of SMACNA.

- K. Smoke Detectors shall be provided and installed by the Electrical Contractor, as specified in Division 26.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Low Pressure Ducts: Seal visible openings and seal air leaks audible at operating conditions.
- B. Medium and High Pressure Duct Leakage Testing:
  - 1. Perform testing in accordance with SMACNA Manual, High Pressure Duct Construction (Chapter 10).
  - 2. Audible Leaks: Test at two inches wg above design operating pressure. Repair significant or noisy leaks.

END OF SECTION 233000



## SECTION 238200 - CONVECTION HEATING AND COOLING UNITS

### PART 1 - GENERAL

#### 1.1 CONDITIONS

- A. The applicable provisions of Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), are hereby made a part of this section and the Contractor is cautioned to read Section 230000 carefully as items of work applicable to this section are included in Section 230000.

#### 1.2 DESCRIPTION OF WORK

- A. Fin tube radiation and fan coil units.

#### 1.3 RELATED WORK

- A. Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).
- B. Section 230900, INSTRUMENTATION AND CONTROLS FOR HVAC.
- C. Section 232000, HVAC PIPING AND PUMPS.
- D. Section 232133, VARIABLE SPEED DRIVES.
- E. Section 233000, HVAC AIR DISTRIBUTION.

#### 1.4 SUBMITTALS

- A. In accordance with Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), furnish the following:
  - 1. Manufacturer's Literature and Data:
    - a. Fin Tube Radiation
    - b. Fan Coil Units
  - 2. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 230000, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC).

#### 1.5 EXTRA MATERIALS

- A. Furnish one set of air filters for each unit.

## PART 2 - PRODUCTS

### 2.1 STEEL PANEL RADIATION

- A. Furnish and install, where shown on plans, steel panel radiation as manufactured by Sterling or Runtal. Unit length, size and capacities shall be as indicated in the equipment schedule.
- B. Unit shall be one piece all welded construction consisting of flattened water tubes welded to headers at each end. Radiator shall include integral heavy gauge all-welded perforated top grille. Units shall have corrugated fins welded to the water tubes for increased convective output. Minimum 32 fins per foot.
- C. Radiator header pipes shall be square 0.109 minimum wall thickness. Headers shall include inlet, outlet, and vent connections as required.
- D. Radiators shall be pedestal mounted. Provide all accessories required.
- E. Panel radiators shall be painted with a gloss powder coat finish, custom color by Architect.
- F. Provide ribbed pipe cover trim as required (finish to match radiators) to blend with the Architectural finishes and as indicated on plans.

### 2.2 FAN COIL UNITS

- A. General - Fan coil units shall be Modine ceiling cassette type complete with casing, cooling coil and hot water coil assembly, drain pan, air filters, fans, motor, fan drive, control package, back duct collar, (bottom duct connection), condensate pump, air vanes, sheet metal shroud, motor switch, and 24V secondary control transformer, and microprocessor controller. Each unit shall be fastened securely to the building structure.
- B. Unit casing shall be manufactured from lightweight galvanized sheet steel with integral fan mounting rails. Casing shall have fire resistant foam insulation (UL94 VO) for thermal and acoustic insulation.
- C. Fans shall be backward curved, centrifugal type, statically and dynamically balanced for quiet operation. Impellers shall be aluminum or fire retardant plastic for lightweight operation. Fan motor shall be multi-speed rotor type with thermal overload protection and sealed for life lubricated bearings.
- D. Air outlet vanes shall be motor driven to auto-sweep the air during operation.
- E. Chilled water and hot water coils shall be manufactured from refrigeration quality copper tubes mechanically bonded to aluminum fins circuited from the headers to provide low pressure drop. Hot water coil shall be suitable for operation with 200°F water and 150 psig water.
- F. Filters shall be provided for each unit and shall be MERV-10 type.
- G. Unit shall include integral condensate pump with check valve and float switch for disabling the unit should the pump become blocked or fail.

- H. Control package shall be electro-mechanical option, factory wired with all necessary relays and safety switches for unit operation. Terminal strip provided at unit for 24V wiring to field mounted Siemens controller specified 23 09 00, INSTRUMENTATION AND CONTROLS FOR HVAC.
- I. Unit shall include metal shroud unit housing cover for exposed ceiling mounting. Shroud housing cover shall be painted Sky White with hammertone finish.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Handle and install units in accordance with manufacturer's written instructions.
- B. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.
- C. Locate variable air volume boxes to provide a straight section of inlet duct for proper functioning of volume controls.
- D. Locate concealed equipment above ceilings at elevations suitable for proper drainage of cooling coil condensate where applicable.

#### 3.2 OPERATIONAL TEST

- A. Perform tests and make reports in accordance with Section 2300 0, HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), and Section 230593, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

END OF SECTION 238200