SECTION 230102 – UNDERGROUND PIPING / BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. The general provisions of contract, including General and Supplementary Conditions and General Requirements apply to work specified in this section.

1.2 CONTRACT DOCUMENTS:

A. The Contract Documents apply to this section.

1.3 RELATED WORK:

A. Related work specified elsewhere includes:

1. Section 232100 - Trenching and Backfilling

1.4 QUALITY ASSURANCE:

A. Reference: Some products and execution are specified in this section by reference to published specifications or standards of the following (with respective abbreviations used).

1. The American Society for Testing and Materials (ASTM).
2. North Carolina Department of Transportation (NCDOT).

B. Standard References: As published by NCDOT: “Standard Specifications for Roads and Structures”, dated January, 1990, referred to hereinafter as “NCDOT Specs”.

C. Manufacturers:

1. Standard: For purposes of designating type and quality for the work under this section, drawings and specifications are based on products manufactured or furnished by manufacturers listed.

2. Source: Products for use on this project shall be one of manufacturer for each function unless noted specifically otherwise herein.

PART 2 - PRODUCTS

2.1 PRE-INSULATED HOT AND CHILLED WATER PIPE:

A. Underground low temperature hot water supply and return shall be a Perma-Pipe PVC Therm System composed of integral sealed units of PVC plastic jacket, Schedule 40 black steel carrier pipe, and insulated with polyurethane foam, completely filling the annular space between the pipe and the jacket. Jacket ends shall be capped with factory installed watertight ends seals. Connection to existing pipe shall be made with welding.

B. Units and fittings shall be joined with integral bell and spigot joints, including a rubber sealing ring.

PART 3 - EXECUTION

3.1 PRE-INSULATED HOT AND CHILLED WATER PIPE:

A. General: Installation of the pipe shall be in conformance with the latest AWWA Standards and the specific recommendations of the pipe manufacturer. The contractor shall be responsible for damage to any existing underground utility system.

B. Excavation and backfilling shall conform to Section 232100.

C. Laying:

1. Pipe, fittings, and valves shall be carefully handled to avoid damage, and while they are suspended over the trench before lowering, they shall be inspected for defects.

2. Before pipe is laid, all dirt, loose material, and moisture shall be removed. After pipe is laid, care shall be taken to avoid the entrance of dirt or water from the trench by the use of tight bulkheads.

3. Concrete, of the class and quantity required shall be placed to prevent movement of pipe and fittings.

D. Immediately after the system is installed in the ditch, a partial backfill shall be made in the middle of each unit leaving the joints exposed for inspection prior to the hydrostatic tests. After all thrust blocks are poured, a hydrostatic of 150 p.s.i.g. shall be required for a period of four hours. No leakage shall be allowed.

E. After hydrostatic testing, final backfill of selected earth shall be hand-placed and hand-tamped of 12" minimum over the top of the jacket. Remainder of the backfill shall be free of large boulders, rocks over 6" in diameter, frozen earth, or foreign matter. The backfill operation shall now be completed by any convenient means. Do not use wheeled or tracked vehicles for tamping.

F. The services of a factory-trained field service instructor shall be required and materials shall be installed in accordance with Manufacturer's recommendations. The Field Service Instructor shall be present during critical stages of the installation and testing.

END OF SECTION 230102

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SECTION 230104 – DIVISION OF WORK (23/26)

PART 1 - GENERAL

1.1 SCOPE OF WORK:

A. This section delineates the DIVISION OF WORK between Division 23 and Division 26.

B. Specific work to be done under Division 26 is hereinafter listed or described. All other work necessary for the operation of Division 23 equipment shall be performed under Division 23.

1.2 DIVISION OF WORK:

A. All individual motor starters for mechanical equipment shall be furnished and installed under Division 23 unless indicated as a part of a motor control center or designated "motor control trough". Motor starters provided in motor control centers and at motor control troughs shall be furnished under Division 26.

B. Under Division 26, power wiring rough-in shall be provided from junction box, trough, starter or disconnect switch, as required by the specific piece of equipment. Equipment final connections shall be provided under Division 26.

C. Duct smoke detectors shall be furnished by Division 26, installed by Division 23, and wired under Division 26. Fire alarm fan shut-down contacts will be provided by Division 26 at the fire alarm control panel or adjacent to smoke detector, for the equipment involved. Extension and wiring of same will be by Division 23 control sub-contractor and shall be closely coordinated between trades.

D. All relays, actuators, timers, alternators, pressure sensors, float, flow switches, pneumatic-electric, and electric-pneumatic switches, aquastats, freezestats, line and low voltage thermostats, thermals, remote selector switches, remote push-button stations, emergency break-glass stations, interlocking, disconnect switches beyond termination point, and other appurtenances associated with equipment under Division 23 shall be furnished, installed and wired under Division 23.

E. All wiring required for controls and instrumentation not indicated on the drawings shall be furnished and installed by Division 23.

F. The sequence of control for all equipment shall be as indicated on the Division 23 drawings and specified under Division 23.

G. Electrical wiring between smoke detector for smoke damper and fire alarm panel shall be provide by electrical contractor. All other wiring for operation of smoke dampers shall be provided by mechanical contractor. All wiring shall be coordinated between trades.

H. Additional power wiring required for HVAC equipment over and above what the electrical contractor is required to provide in accordance with the electrical drawings shall be provided by the HVAC contractor.

END OF SECTION 230104

SECTION 230210 - CONCRETE & MASONRY WORK

PART 1 - GENERAL

1.1 SCOPE OF WORK:

A. Provide all concrete and masonry work as indicated on the heating and cooling and ventilating contract drawings, unless it is indicated that it will be by the general contractor. This includes bases for equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. All cement, gravel, sand, reinforcing rod, brick, block and other materials comply with the requirements for those materials in the specifications for the general contractor.

PART 3 - EXECUTION

3.1 GENERAL

A. The workmanship and manner of placing the materials shall comply with the requirements for those items in the specifications for the general contract.

B. Bases shall have smooth tops and cambered edges.

END OF SECTION 230210

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SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.

B. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials, or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.

C. The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances, and services necessary for the satisfactory installation of the complete and operating Mechanical Systems indicated or specified in the Contract Documents.

D. Any materials, labor, equipment, or services not mentioned specifically herein which may be necessary to complete any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.

E. It is not the intent of this Section of the Specifications to make any Contractor, other than the Construction Manager responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Construction Manager to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

F. The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer's convenience and is not intended to define a subcontractor's scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described, and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices, and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

G. It is the intent of the Contract Documents to deliver to the Owner a new, complete, and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

H. In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.

I. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.

J. Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.

1.3 Definitions and Abbreviations:

A. Contractor - Any Contractor whether bidding, proposing, or working independently or under the supervision of a Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the Construction Manager.

B. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.

C. Architect - The Architect of Record for the project.

D. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.

E. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency, or entity for any part of the work required under this contract.

F. The Project - All of the work required under this Contract.

G. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.

H. Provide - Furnish and install complete, tested, and ready for operation.

I. Install - Receive and place in satisfactory operation.

J. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.

K. Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.

L. ADA - Americans with Disabilities Act.

M. ANSI - American National Standards Institute.

N. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.

O. ASME - American Society of Mechanical Engineers.

P. IBC - International Building Code.

Q. NEC - National Electrical Code.

R. NEMA - National Electrical Manufacturers Association.

S. NFPA - National Fire Protection Association.

T. OSHA - Office of Safety and Health Administration.

U. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.

V. UL - Underwriters Laboratories.

1.4 INTENT AND INTERPRETATION:

A. It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation, tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.

C. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

D. The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.

E. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

1.5 PLANS AND SPECIFICATIONS:

A. The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

B. The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.

H. Each Bidder/Proposer shall review all Plans in the Contract Documents to ensure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular ensure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

I. Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

K. Where within the Contract Documents the word “typical” or “typ.” is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.

L. Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

M. The Contractor shall provide a layout confirmation of equipment rooms to verify that all of the equipment submitted and approved will in fact fit into the proposed space and have adequate clearance for service. See COORDINATION DRAWINGS SECTION.

1.6 EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:

A. When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of cities, towns, states, or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.

D. Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which, they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.

1.7 QUALIFICATIONS OF CONTRACTOR/WORKERS:

A. All Mechanical Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.

B. All mechanical subcontractors bidding the mechanical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.

C. All mechanical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.

D. The Contractor shall hold all required licenses in the State which the work is to be performed.

E. The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor, whether in existing or new building construction shall be performed by a Licensed Master HVAC Contractor. This includes any Contractor installing HVAC systems, piping, and ductwork.

F. All sheet metal, insulation and pipe fitting work shall be installed by workers normally engaged in this type of work.

G. All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

1.8 HAZARDOUS MATERIALS:

A. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling, or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.

D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents, or consultants. Also, the Contractor further agrees to defend, indemnify, and hold CMTA, its principals, employees, agents, and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

E. No asbestos or mercury containing materials shall be installed in this project.

F. No asbestos - containing materials are to be purchased, supplied by any person supplying or installed in or on property by any person performing work. Furthermore, all products marked "May contain Mineral Fiber" will be assumed to contain asbestos unless the manufacturer provides written certification that no asbestos fibers are present in the product and identifies the fibers for which the product is marked. An exception to this rule can be made where a faculty or staff member certifies that the use of asbestos is essential to an ongoing research or production project and works with Environmental Health and Safety Department to ensure that the material is used, stored, and disposed of in safe and legal manner.

1.9 COORDINATION DRAWINGS:

A. Detailed electronic coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for "preparation of coordination drawings". This line-item value shall be approved by the Engineer. The Engineer and the Engineer's Field Inspector shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.

B. Coordination Drawings shall be provided on this project. Drawings shall be prepared in electronic format utilizing AutoCad or similar drafting software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.

C. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits, and other conduits 2" and larger, and piping and components in ceiling spaces. The Coordination Drawings shall be prepared by the Fire Protection Contractor. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations.

D. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc will be installed with respect to the sheetmetal fabrication drawings and other trades. The sheetmetal ductwork and gravity piping systems shall be given the first priority. Each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.

E. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
   1. All supply/return/exhaust ductwork.
   2. All above slab sanitary and roof drainage piping.
   3. HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
   4. Electrical conduits which are 1.5" in size and greater.
   5. Cable tray and bridal ring paths.
   6. Multiple smaller piping/conduits hung on a common trapeze hanger.

7. All wall, roof, floor penetrations.

F. After completion of the Final Coordination Drawings, a Final Review with all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meetings will be required to insure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete pdf and 30x42 set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Prime Contractor, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.

G. Each Contractor shall insure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts, and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Prime Contractor, Owner, Architect and Engineer for their Records.

H. The Mechanical contractor is responsible to the Construction Manager for the shop drawing layout of the following rooms and details:
1. Concrete pads
2. Equipment room layouts with actual equipment
3. Roof layouts
4. Congested areas above ceilings adjacent to mechanical and electrical room
5. Dimensioned ductwork shop drawings

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION OF SITE CONDITIONS

A. Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.

B. Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

3.2 CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:

A. The Contractor shall give all necessary notices, obtain, and pay for all permits, government sales taxes, fees, inspections, and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.

B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus, and plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.

D. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

E. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.

F. All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Building Code and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.

G. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

H. Where minimum code requirements are exceeded in the Design, the Design shall govern.

I. The Contractor shall insure that their work is accomplished in accord with the OHSA Standards and that they conduct their work and the work of their personnel in accord with same.

J. All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.

K. Discharge of any toxic, odorous, or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.

L. Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

3.3 SUPERVISION OF WORK:

A. The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

3.4 CONDUCT OF WORKERS:

A. The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens, or debilitating drugs on the job site is strictly forbidden.

3.5 COOPERATION AND COORDINATION WITH OTHER TRADES:

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than ¼" = 1'-0", clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

3.6 GUARANTEES AND WARRANTIES:

A. The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of final acceptance. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. All VFD's shall have a two-year warranty. (Parts and Labor).

C. Provide all warranty certificates to Owner. All warranties begin starting at the final acceptance date, submit warranty certificates accordingly.

3.7 COST BREAKDOWNS (SCHEDULE OF VALUES):

A. Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

B. The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:

1. Mechanical Shop Drawings
2. Motor Load Coordination with other subcontractors
3. Mechanical Record Drawings & Acceptance
4. Mechanical O&M Manuals & Acceptance
5. Mechanical Owner Training & Acceptance
6. Spare Parts
7. Coordination Drawings
8. Mechanical Identification Materials & Labor
9. HVAC Piping Materials & Labor
10. HVAC Piping Testing, Cleaning, Documentation, Acceptance, etc.
11. HVAC Piping Purging, Flushing, Cleaning
12. Insulation (Piping) Materials & Labor
13. Insulation (Ductwork) Materials & Labor
14. Sheetmetal Equipment
15. Sheetmetal Materials & Labor
16. Sheetmetal Shop Fabrication

17. Ductwork Air Leakage Testing, Documentation, Acceptance, etc.
18. Filters and Racks Materials & Labor
19. Heat Pump Equipment & Labor
20. Heat Pump Startup, Testing, Documentation, Training, Acceptance, etc.
21. Other HVAC Equipment & Labor
22. Other HVAC Equipment Startup, Testing, Documentation, Training, Acceptance, etc.
23. Chemical Treatment Materials & Labor
24. Chemical Treatment Pre-Testing
25. Chemical Treatment Startup, Testing, Documentation, Training, Acceptance, etc.
26. Controls Front-end Interface
27. Controls Commissioning Plan
28. Controls Shop Drawings
29. Controls Materials & Labor
30. Controls Graphics
31. Controls Record Drawings
32. Controls Startup, Commissioning, Testing, Documentation, etc.
33. Controls Training and Acceptance
34. Test and Balance Materials & Labor
35. Test and Balance Pre-Testing
36. Test and Balance Initial Report, Final Report and Acceptance

3.8 CHANGES IN MECHANICAL WORK:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.9 CLAIMS FOR EXTRA COST:

A. REFER TO GENERAL AND SPECIAL CONDITIONS.

3.10 MATERIALS AND WORKMANSHIP:

A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

B. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.

C. Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.

D. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase, and ampacity. Pumps and fans shall have a data plate indicating horsepower, pressure, and flow rate.

3.11 TEMPORARY SERVICES:

A. The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.

B. All temporary services shall be removed by Contractor prior to completion of work.

3.12 SURVEY, MEASUREMENTS AND GRADE:

A. The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations, and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

3.13 PROTECTION OF EQUIPMENT:

A. The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen, or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense. All ductwork with open ends shall be covered with plastic during construction.

3.14 REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

3.15 EQUIPMENT SUPPORT:

A. Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform, or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

3.16 DUCT AND PIPE MOUNTING HEIGHTS:

A. All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6” clear including insulation, unless otherwise noted.

3.17 BROKEN LINES AND PROTECTION AGAINST FREEZING:

A. No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily ensure that freezing will not occur. If in doubt, contact the Engineer.

3.18 WEATHERPROOFING:

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

3.19 ACCESSIBILITY:

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.

C. Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

3.20 SCAFFOLDING, RIGGING AND HOISTING:

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

3.21 CONCRETE WORK:

A. The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.

B. In the absence of other concrete Specifications, all concrete related to Mechanical work shall be 3500 psi minimum compression strength at 28 days curing, slump: 4” ± 1”, air entrainment 4.5% water to cement ratio 0.5 and shall conform to the standards of the American Concrete Institute Publication AC1-318. Heavy equipment shall not be installed on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into new and existing floors to anchor pads.

C. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾” and tool horizontal edges with ¾” radius.

D. In general, unless otherwise noted, concrete pads for equipment shall be 4" thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

3.22 RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:

A. Refer to Civil Plans and Specifications.

3.23 MAINTENANCE OF EXISTING UTILITIES AND LINES:

A. The locations of all piping, conduits, cables, utilities, and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.

B. Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.

D. Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

3.24 CLEANING:

A. The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

C. Ductwork and piping shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork or insulation (pipe or duct) if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

3.25 TEMPORARY USE OF EQUIPMENT:

A. The permanent heating when installed, may be used for temporary services, with the consent of the Engineer. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.

B. Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

C. Warranties shall begin at final acceptance regardless of temporary use of equipment or not.

D. A pre-start-up conference shall be held in accordance with EQUIPMENT/CONTROLS START-UP AND VERIFICATION in this section.

E. For Heat Pump Units during all phases of construction:
   1. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at final acceptance. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

2. On the outside of all exhaust air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the "construction" filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.
3. At final acceptance of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.

F. For Outside Air Units during all phases of construction:
1. These units shall not be used for temporary heating and cooling by the Contractor. They shall, however, be made operational, tested, etc. as specified during construction by the Contractor. Three complete sets of filters are required for each unit. In each unit, install one set of filters during construction. In each unit, install one set of filters at final acceptance. For each unit, leave third set of filters in boxes in appropriate mechanical room as a spare set for the Owner. Dispose of all construction filters.
2. At final acceptance of the project the entire unit shall be cleaned to present a like "new" unit for the Owner and all filters shall be replaced with new.

3.26 NOISE, VIBRATION OR OSCILLATION:

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound, or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means.

C. Unitary equipment, such as room units, exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.

D. The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

3.27 EQUIPMENT/CONTROLS STARTUP & VERIFICATION:

A. The Contractor and their Subcontractors shall include in the bid to provide equipment and controls startup and verification for ALL Mechanical Systems specified for this project.

B. A pre-start-up conference shall be held with the Architect, Engineer, Owner, Construction Manager, Mechanical Contractor, Electrical Contractor, Controls Contractor, Test and Balance Contractor, and the Manufacturer's providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.

C. Specific line-items shall be included on the schedule of values by each Trade for "equipment and controls startup". These line-item values shall be approved by the Engineer. The Engineer, Owner and the Engineer's Field Inspector(s) shall closely monitor progress and quality of the equipment and controls startup and may withhold pay requests as deemed appropriate until satisfactorily completed.

D. Specific startup/verification specifications are included throughout the Mechanical Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third-party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.

E. The Contractor shall be responsible for completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment noted. Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
   1. Outside Air Units
   2. Variable Frequency Drives
   3. Heat Pumps – (Include attached forms in documentation)

F. Except for the specific equipment specified in this Specification Section, the manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. Where "manufacturer" startup is not specified, then this Contractor shall perform startup services in strict accordance with manufacturer's instructions. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.

G. The Contractor shall "zip-tie" a start-up report to each piece of equipment in a clear plastic cover. Once start-up completion is verified by the Engineer the Contractor shall remove all reports and consolidate them into close-out documentation. The Contractor shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists.

3.28 INSPECTION, APPROVALS AND TESTS:

A. Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.

B. The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.

C. The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

D. Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

E. Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

3.29 ABOVE-CEILING AND FINAL PUNCH LISTS:

A. The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.

B. Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.

C. When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review. The Contractor’s representative may be requested at the inspections.

3.30 OPERATING INSTRUCTIONS:

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.

C. Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

3.31 RECORD DRAWINGS:

A. The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts, and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.

B. All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. This shall include underground geothermal piping mains. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad ".dwg" format and ".pdf" format. The survey information shall be included in the closeout documentation.

3.32 COMMISSIONING: CONTRACTOR RESPONSIBILITIES:

A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
   1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
   2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
   3. Attend commissioning team meetings.
   4. Integrate and coordinate commissioning process activities with construction schedule.
   5. Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority.
   6. Review and accept commissioning process test procedures provided by the Commissioning Authority.
   7. Complete commissioning process test procedures.
   8. A manufacturer authorized technician, controls contractor, and mechanical contractor shall demonstrate the full sequence of operation and bas point integration.

END OF SECTION 230500

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SECTION 230501 - SCOPE OF THE HVAC WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.2 SCOPE

A. The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include but is not necessarily limited to the following paragraphs.

B. Installation of all equipment per the manufacturer’s instruction, whether specifically detailed or not.

C. Provide all required motor starters, etc. not provided under the electrical sections.

D. Thorough instruction of the Owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

E. Thorough coordination of the installation of all piping, ductwork, equipment, and any other material with other trades to ensure no conflict in installation.

F. Approved supervision of the mechanical work.

G. Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.

H. Cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.

I. Cutting, patching, sleeving, concrete work, etc., required to construct the HVAC systems.

J. Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.

K. Equipment and controls start-up, verification and documentation as specified.

L. Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts, and other specified closeout documentation.

M. Required schedule of values breakdown.

N. Preinstallation meetings and equipment mockups.

O. Complete interior and exterior geothermal system and required test results.

P. Complete heating, ventilation, and air conditioning systems.

Q. All mechanical exhaust systems.

R. Pipe, duct, and equipment identification.

S. All insulation associated with mechanical systems.

T. Condensate drainage systems.

U. All required pressure testing, flushing, purging, pressure and flow testing requirements.

V. Final coordination and connection of all mechanical equipment furnished by others (e.g., kitchen equipment, appliances, CTE).

W. All required controls, including self checkout and commissioning.

END OF SECTION 230501

SECTION 230502 - SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. TESTING, ADJUSTING AND BALANCING FOR HVAC
2. DUCT INSULATION.
3. HVAC PIPING INSULATION
4. INSTRUMENTATION AND CONTROL FOR HVAC
5. FACILITY MONITORING SYSTEM
6. VARIABLE FREQUENCY MOTOR CONTROL
7. HYDRONIC PIPING
8. HYDRONIC PUMPS
9. HVAC WATER TREATMENT
10. METAL DUCTS
11. AIR DUCT ACCESSORIES
12. DIFFUSERS, REGISTERS & GRILLES
13. INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

1.2 SCOPE

A. The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 01 requirements for shop drawing submittal requirements.

B. The Engineer’s review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations, and information that pertains to fabrication and installation; dimensions. weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.

PART 2 - PRODUCTS

2.1 SHOP DRAWINGS

A. Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:
1. Access Doors
2. Air Filtration & Components
3. Electric Heaters
4. Chemical Treatment and Test Reports
5. Ductwork Accessories/Volume Dampers
6. Firestopping
7. Metal Ducts & Fittings
8. Facility Management System
9. Instrumentation and Control for HVAC
10. Exhaust Fans
11. Air Separator and Expansion Tank
12. Insulation
13. Meters and Gages
14. Louvers
15. Hydronic Piping
16. Pumps and Hydronic Specialties
17. Register, Grilles & Diffusers
18. System Verification Check Lists
19. Valves
20. Variable Frequency Drives
21. Indoor, Central-Station Air-Handling Units

B. Special Notes: For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
1. Detailed operating instructions
2. Detailed maintenance instructions including preventive maintenance schedules.
3. Addresses and phone numbers indicating where parts may be purchased.
4. Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
5. Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
6. Start-up reports, service records and test reports.

C. Shop drawings for the Facility Monitoring System & Instrumentation and Control for HVAC, shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.
1. The TCC shall not start the project installation until the shop drawing submittals have been reviewed by the Engineer.
2. Submittals shall include hardware, end devices, ancillary control components, a written operating sequence, unitary control wiring, building floor plans showing communication cabling and labels as well as logic flow diagrams. All submittals shall be provided on paper and electronically in PDF format.

3. Submittals shall contain one control drawing per specified system and equipment. Drawing shall include point descriptors (DI, DO, AI, AO), addressing, and point names. Each point names shall be unique (within a system and between systems). For example, the point named for the mixed air temperature for AHU #1, AHU #2, and AHU #3 shall not be MAT but should be named AHU#1MAT, AHU#2MAT, and AHU#3MAT. The point names should be logical and consistent between systems and AHU's. The abbreviation or shorthand notation (e.g., MAT) shall be clearly defined in writing by the TCC.
4. Control diagrams shall identify: System being controlled (attach abbreviated control logic text, all digital points, analog points, virtual points, all functions (logic, math, and control) within control loop, legend for graphical icons or symbols, definition of variables or point names and detailed electric connections to all control devices and sensors.
5. Points list shall include all physical input/output. Points list shall be provided in both hard copy and in electronic format and shall include Name, address, engineering units, high and low alarm values, and alarm differentials for return to normal condition, default value to be used when the normal controlling value is not reporting, message and alarm reporting as specified, identification of all adjustable points and description of all points.
6. Submittals shall contain floor plans depicting DDC control devices (control units, network devices, LAN interface devices, and power transformers as well as static pressure sensor in duct and temperature sensors in rooms) in relation to mechanical rooms, HVAC equipment, and building footprint.
7. Submittals shall contain DDC system architecture diagram indicating schematic location of all control units, workstations, LAN Interface devices, gateways, etc. Indicate address and type for each control unit, Indicate protocol, baud rate, and type of LAN per control unit.
8. Electrical wiring diagrams shall include motor start, control, and safety circuits and detailed digital interface panel control point termination diagrams with all wire numbers and terminal block numbers identified. Indicate all required electrical wiring. Provide panel termination drawings on separate drawings. Clearly differentiate between portions of wiring that are existing, factory-installed and portions to be field-installed.
9. Show all electric connections of the controls system to equipment furnished by others complete to terminal points identified with manufacturer's terminal recommendations.
10. TCC shall provide one complete drawing that shows the control-wiring interface with equipment provided by others.
11. Submittals shall include project specific graphic screens for each system including a picture of the screen with a list of the variables to be placed on the screen.
12. Submittals shall include TCC's hardware checkout sheets and test reports.
13. Submittals shall include the agenda for approval by the engineer and owner of the specified training periods. See training section for requirements.
14. Provide complete panel drawings that are:
    a. Clearly labeled and schematic or drawn to scale.
    b. Show the internal and external component arrangement so that the operators can identify the components by their position if the labels come off.
    c. Wiring access routes shall also be identified so that Class 1 wiring is separated from Class 2 and 3 and so high voltage wiring is segregated from low voltage wiring.
    d. Complete identification of all control devices (manufacturer's type, number, and function).
    e. Provide details for labeling all wiring, control devices, and controllers.

f. Material and equipment descriptive material such as catalog cuts, diagrams, performance curves, and other data to demonstrate conformance with specifications shall be provided.

15. Include room schedule including a separate line for each terminal unit, heat pump, etc. indicating location and address.
16. Include control valve schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: code number, configuration, fail position, pipe size, valve size, body configuration, close-off pressure, capacity, valve Cv, design pressure, and actuator type.
17. Include control damper schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including code number, fail position, damper type, damper operator, duct size, damper size, mounting, and actuator type.

D. O&M manuals and closeout documents for facility monitoring systems and control for HVAC and variable frequency motor control.
1. Refer to Mechanical Specification Section – REQUIRED SHOP DRAWINGS, ETC. for additional requirements.
2. Operating instructions, maintenance procedures, parts and repair manuals shall be supplied. Repair manuals shall include detailed instructions in the setup, calibration, repair, and maintenance of all equipment furnished. Also supplied with these manuals will be a complete parts listing of all devices supplied which is to include part numbers and model numbers of all parts and component parts along with exploded views of devices.
3. All as built drawings (wiring diagrams, flowcharts, floor plans, etc.) shall also be supplied to the owner electronically in PDF format.
4. System specific wiring, control diagrams, sequence of operation and points lists shall be as installed in each control panel. This means as-built drawings, not design (submittal) drawings.
5. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and downloading the entire unitary data base or any part of the automated system for backup or archiving.
6. Supply one copy of the software programming manual (hard copy and PDF format). The manual shall describe all furnished software. The manual shall be oriented to programmers and shall describe calling requirements, data exchange requirements, data file requirements, and other information necessary to enable proper integration, loading, testing, and program execution.
7. Provide a Bill of Materials with each schematic drawing. List all devices/equipment and match to schematic and actual field labeling. Provide quantity, manufacturer, actual product ordering number, description, size, accuracy, operating ranges (voltage, temperature, pressure, etc.), input/output parameters, etc.
8. Maintenance manual shall include copies of signed-off acceptance test forms, commissioning reports, start-up reports, etc.
9. The TCC shall turn over to owner two (2) sets of computerized back-ups of the complete temperature control system.

E. The Contractor shall submit shop drawings for the kitchen range hood system(s) along with all required supporting documentation agency and review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineer. Refer to Specification Section – HVAC EQUIPMENT and Specification Section SHEETMETAL for additional requirements.

F. The Contractor shall submit shop drawings for the boilers along with all required supporting documentation and agency review fees to the authority having jurisdiction and receive approval prior to submittal to the Engineers.

G. Shop drawings for Diffuser, Registers and Grilles, shall include a room-by-room schedule indicating devices installed. Also note ceiling and installation.

H. Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.

I. The Contractor shall submit project specific UL listed firestopping installation drawings to the authority having jurisdiction where required for their approval as required.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide all shops in electronic/PDF format. The Engineer's comments will be returned in electronic format.

B. Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.

C. Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

D. All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

E. The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.

F. It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the

proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.

G. Prior to ordering any materials or rough-in of any kind, the HVAC Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Construction Manager, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

H. Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

I. If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

J. Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.

K. All submittals for HVAC equipment shall include all information specified and scheduled. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.

L. All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.

M. Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

END OF SECTION 230502

SECTION 230503 – VOC REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This work includes provisions to reduce the quantity of indoor air contaminants that are odorous or potentially irritating and to maximize water efficiency within the building.

1.2 LOW-EMITTING MATERIALS

A. INTENT: Reduce the quality of indoor air contaminants that are odorous or potentially irritating to provide installer and occupant health and comfort.

1.3 REQUIREMENTS AND SUBMITTALS

A. Meet or exceed VOC limits for adhesives, sealants, paints, composite wood products, and carpet systems as follows:
   1. Adhesives must meet or exceed the VOC limits of South Coast Air Quality Management District Rule #1168 by, AND all sealants used as a filler must meet or exceed Bay Area Air Resources Board Reg. 8, Rule 51.
      a. Provide a cut sheet and a Material Safety Data Sheet (MSDS) for each adhesive used in the building highlighting VOC limits.
      b. Provide a cut sheet and a Material Safety Data Sheet (MSDS) for each sealant used in the building highlighting VOC limits.
   2. Paints and coating must meet or exceed the VOC and chemical component limits of Green Seal requirements.
      a. Provide a cut sheet and Material Safety Data Sheet (MSDS) for each paint or coating used in the building highlighting VOC limits and chemical component limits.

1.4 SUMMARY OF REFERENCED STANDARDS

A. South Coast Rule #1168 by the South Coast Air Quality Management District

B. Regulation 8, Rule 51 of the Bay Area Air Resources Board (June 5, 1996) for sealants:

C. Limits on VOCs in grams per liter for sealants and sealant primers are as follows:

SEALANTS	VOC LIMIT (G/L)
General Sealant Primers	250
General - nonporous	250
General - porous	775
Other	750

D. Green Seal Product Specific Environmental Requirements

1. The Green Seal standard is intended for paints and anti-corrosive paints. Both interior and exterior paints are addressed by the standard. Limits on VOCs in grams per liter for paints and anti-corrosive paints are as follows:

INTERIOR COATINGS	VOC LIMIT (G/L)
Non-flat	150
Flat	50
EXTERIOR COATINGS	
Non-flat	200
Flat	100

END OF SECTION 230503

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. VARIABLE FREQUENCY MOTOR CONTROL
3. HYDRONIC PUMPS
4. DEDICATED OUTDOOR-AIR UNITS
5. WATER-SOURCE UNITARY HEAT PUMPS

1.2 SCOPE

A. Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall ensure a complete, 100% functional, tested, inspected, and approved systems. Claims for additional cost or change orders will immediately be rejected. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

B. Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e., voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor, and their sub-contractors.

PART 2 - PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.

B. Provide shaft grounding rings for all VFD driven motors.

C. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.

D. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

E. Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.

F. Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.

G. Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.

H. Unless otherwise noted or required by application, motors shall confirm to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design “A” or “B”. Utilize design "C" motors where required for high starting torque.

I. Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.

J. Provide inverter rated motors where variable frequency drives are utilized. Motor shall be premium efficiency type with Class F insulation and shall conform to NEMA MG 1 parts 30 and 31. Inverter duty rated motors shall have a temperature rating for 40 deg C ambient environment with maximum of 105 deg C temperature rise.

K. Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

L. Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.

M. Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.

N. Provide energy efficient motors with a minimum EPACT efficiency in accordance with 10 CFR Part 431 published by the US Dept of Energy (Subpart B Electric Motors and Subpart X Small Electric Motors) as defined by NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors. If efficiency not specified, motors shall have a minimum efficiency as listed below:

1.	1 hp - 82.5%	7.5 hp – 89.5%	30 hp – 92.4%
2.	1.5 hp – 84.0%	10 hp – 89.5%	40 hp – 93%
3.	2 hp – 84%	15 hp – 91%	50 hp – 93%
4.	3 hp – 87.5%	20 hp – 91%	60 hp – 93.6%
5.	5 hp – 87.5%	25 hp – 92.4%	75 hp – 94.1%

O. On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

2.2 MOTOR STARTERS

A. Provide motor starters where indicated on the mechanical equipment schedules or elsewhere in the Contract Documents.

B. Motor starters shall be NEMA style. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

C. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be the reduced voltage open-transition type. Do not utilize closed transition starters unless specifically indicated.

D. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See remaining paragraphs of the Part and mechanical schedules for further requirements.

E. Contacts shall be silver-alloy, double-break type except NEMA size 8 and 9 shall be single-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.

F. Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, except for size 8 and 9 which shall be hand wound. Provide coil clearing contact as required.

G. Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.

H. Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated for automatic control.

I. Provide NEMA Class 20 resetable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resetable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used depending on type of motor duty encountered.

J. Provide at least one N.O. auxiliary contact (field-convertible to N.C. operation) with each starter. All starters shall have space for two additional single-pole contacts.

K. All starters shall be thru-wiring type.

L. Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 7½ H.P. or larger.

2.3 ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

A. All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.

B. The equipment manufacturer shall provide internally mounted fuses with the equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.

C. It shall be the Contractor's responsibility to assure that all mechanical equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.

D. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.

E. Refrigeration condensing units with internal compressors shall be furnished with integral starter.

F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.

G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.

H. Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.

I. Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

2.4 REQUIREMENTS FOR HVAC EQUIPMENT 3/4 H.P. OR LESS

A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, VAV boxes, unit heaters, unit ventilators, exhaust fans, fans, fan coil units, cabinet heaters, DDC temperature control panels, etc.

B. Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.

C. Provide transformer within unit as required to provide low voltage A.C. for thermostat control.

D. Provide internal fusing for unit motor and other loads in fuse block or in-line fuse holder.

E. Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

PART 3 - EXECUTION: (NOT APPLICABLE)

END OF SECTION 230513

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SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Install expansion loops in locations shown on the drawings.

END OF SECTION 230516

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SECTION 230517 – SLEEVING AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. HVAC PIPING INSULATION
2. HYDRONIC PIPING

1.2 SCOPE

A. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

B. All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor’s expense.

PART 2 - PRODUCTS

2.1 SLEEVES

A. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation. Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.

2.2 FIRESTOPPING

A. Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.

B. The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):

1. One, two or three hour fire rated concrete floor - 3M #5300-MPC8.
2. One, two or three hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
3. One hour fire rated gypsum wallboard - 3M #5300-MPC7.
4. Two hour fire rated gypsum wallboard - 3M #5300-MPC7.

C. The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
1. One, two and three hour fire rated concrete floor - 3M #5300-IMP2.
2. One, two and three hour concrete block wall - 3M #5300-IMP2.
3. One hour fire rated gypsum wallboard - 3M #5300-IMP4.
4. Two hour fire rated gypsum wallboard - 3M #IMP7.

D. Refer to 07 84 13 for additional manufacturers.

E. HVAC ducts penetrating a one or two hour fire rated wall or floor shall be firestopped per 3M #5300-HVD1.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.

B. The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.

C. The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing, or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.

3.2 CUTTING

A. All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor, and ceiling finishes as well as to provide a fastening means for devices, etc.

B. The Mechanical Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:

C. New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.

D. New Openings over 48" in width: Consult with Structural Engineer.

E. No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

F. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

3.3 PATCHING, REPAIRING AND FINISHING

A. Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed by the contractor of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.

C. Piping and ductwork passing through floors, ceilings and walls in finished areas shall be fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.

D. Flanged metal collars shall be provided around all ducts, flues, pipes, etc. at all wall penetrations, both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2” in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

3.4 FIRESTOPPING

A. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.

B. All mechanical pipes and ducts penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.

D. Where the installation of ductwork requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.

E. The manufacturer of the firestopping materials shall provide onsite training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.

F. Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

1.2 SUMMARY

A. Install one-piece escutcheons on both sides of all pipe penetrations through floors, ceilings, and walls. Coordinate requirements of fire rated walls.

PART 2 - PRODUCTS

2.1 GENERAL

A. Escutcheons for New Piping: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an ID that completely covers opening.
   1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   2. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
   3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
   4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
   5. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
   6. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.

PART 3 - EXECUTION

3.1 GENERAL

A. Install one-piece escutcheons on both sides of all pipe penetrations through floors, ceilings and walls. Coordinate requirements of fire rated walls.

END OF SECTION 230518

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SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Refer to the following sections:
1. Shop Drawings, Maintenance Manuals and Parts Lists for HVAC
2. Identifications for HVAC Piping, Ductwork and Equipment
3. Testing, Balancing, Lubrication & Adjustments for HVAC
4. HVAC Piping Insulation
5. HVAC Commissioning
6. Instrumentation and Control for HVAC
7. Facility Monitoring System
8. Pipe, Pipe Fittings, & Pipe Support
9. Sheet Metal

PART 2 - PRODUCTS

2.1 THERMOMETERS AND PRESSURE GAUGES:

A. Gauges and thermometers shall be Miljoco, Marsh, Trerice, or Weksler.

B. Digital thermometers shall be solar powered industrial thermometer. The range shall be -50°F/300°F with an accuracy of 1% or 1°, whichever is greater. The display shall be a 3/8” LCD digit. Use where specifically indicated on the drawings.

C. Water thermometers shall be blue-reading spirit liquid-in-glass type with 9” scale, powder coated cast aluminum case and stem socket of length as required by system. Accuracy to be plus or minus 1 scale division. Lens to be plastic. Hot water thermometer shall have a 30°F to 240°F range and chilled water thermometer shall have a 0°F to 120°F range.

D. Pressure gauges shall be Bourdon Type, circular, 4-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks. Accuracy to be plus or minus 1%. Water pressure gauges shall have 0 to 100 PSI range.

2.2 METERS

A. WATER FLOW METERS
1. Liquid flow measurement sensor shall be of the electro-magnetic flowmeter type and shall be bi-directional, microprocessor-based, and flange mounted.
2. The meter shall be sized to the appropriately for the range of flow for the system. The flow sensor liner shall be suitable for the media it will be measuring.
3. The electrodes shall be SS or Hasteloy C.
4. The transmitter shall be provided with an integral universal wall/pipe mounting bracket and cable for remote mounting, integral LCD display, and NEMA 4X housing, shall indicate flow rate, totalize flow, and shall have an isolated 2-wire 4-20 mA linear output signal and a pulsed output signal for totalization. transmitter shall be located at the DDC panel array unless the maximum available cable length is exceeded.
5. The unit shall be factory calibrated for the specified flow and shall be calibrated in both directions if the application is bi-directional. Calibration shall be minimum three point.
6. The unit shall be mounted in an accessible location and shall be capable of being field calibrated and reprogrammed from the outside housing via magnetic probe or integral keypad menu switching. Unit shall have the capability to maintain flow total in non-volatile memory.
7. Power to the unit shall be 120 VAC, fed from an aux. control panel, with a separate disconnect and fuse. Disconnect and fuse to be located in the auxiliary panel.
8. The flow meter shall be provided with a 2-year warranty and application performance guarantee.
9. The flowmeter and transmitter as a unit shall have the following minimum characteristics.
10. Flowmeter Liner: Water: Polyurethane or Teflon b. Accuracy: (Over an operating range of 30-120 deg. F.)
    a. At 1 to 33 feet per second velocity: +/-0.5% of rate.
    b. At 0.3 feet per second velocity: +/-2% of rate.
    c. Unit shall provide two analog 4-20 mA signals or a single 4-20 mA signal and a digital contact closure on reverse flow.
11. Provide a phenolic tag for each transmitter to identify service (i.e. SECONDARY CHILLED WATER FLOW, etc).
12. Approved Manufacturers
    a. Kent Taylor ABB (Magmaster)
    b. Sparling
    c. EMCO
    d. OnicoN

B. BTU METER:
1. Provide and install ONICON System -10 MTU Meter system or approved equal, including flow meter per above , supply and return temperature sensors and wells and control panel.
2. The entire system shall be factory calibrated and programmed for particular system where installed (sub-surface heating system) and shall be re-programmable at the control panel keypad. Furnish a certificate of calibration for each BTU meter.
3. Interface the control panel into the DDC controls system to obtain energy totals, flow rates, temperatures (supply and return) for trending. I

4. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration.
5. Provide with remote display where indicated.
6. Approved Manufacturers
   a. Kent Taylor ABB (Magmaster)
   b. Sparling
   c. EMCO
   d. OnicoN

PART 3 - EXECUTION

3.1 INSTALLATION

A. The installing contractor shall supply and install pressure gauges and / or thermometers in readily accessible locations in piping adjacent to the equipment served, such that they can be easily read from a standing position on the floor (do not install any higher than 7’-0” AFF). Gauges shall be installed in the entering and leaving side of all service piping. Contractor shall install P/T ports on the entering and leaving side of all hydronic heat transfer coils, control valves, flow meters, pumps, adjacent to each pressure gauge, and upstream and downstream of each differential pressure flow device, etc. Installation of gauge cocks and P/T ports shall be used to facilitate the “Sensor Calibration Check” phase of the Cx / functional performance testing (FPT) procedures.

B. Mount thermometers in approved wells with sizing to allow accurate reading of water temperature. The contractor is responsible to verifying piping wall thickness to ensure the correct well sizing is selected. Do not make direct contact of base with fluid in pipe.

C. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.

D. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

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

F. Install thermowells with extension on insulated piping.

G. Fill thermowells with heat-transfer medium.

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

I. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

J. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

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

L. Install remote-mounted pressure gages on panel.

M. Install valve and snubber in piping for each pressure gage for fluids.

N. Install test plugs in piping tees.

O. Install flow indicators in piping systems in accessible positions for easy viewing.

P. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

Q. Install flowmeter elements in accessible positions in piping systems.

R. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

S. Install permanent indicators on walls or brackets in accessible and readable positions.

T. Install connection fittings in accessible locations for attachment to portable indicators.

U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

V. The Contractor shall include all meters, thermometers, pressure gauges and/or compound gauges at the locations indicated. All pressure gauges and/or compound gauges shall be provided with ¼ turn ball valves to allow the gauge to be removed and replaced without shutting down system.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

SECTION 230523 - VALVES

PART 1 - GENERAL:

1.1 SCOPE OF WORK:

A. This work shall consist of furnishing all labor, material, equipment, and services necessary for the installation of all equipment specified hereinafter.

B. Equipment and components principally relevant to this section include:
1. Gate Valves
2. Check Valves
3. Globe Valves
4. Balancing Cocks
5. Ball Valves
6. Butterfly Valves
7. Other items where shown on the drawings or as specified.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL:

A. Furnish and install valves shown on the drawings, specified herein and/or necessary for the control and easy maintenance of all piping and equipment. All valves shall be first quality of approved manufacture, shall have proper clearances, and shall be tight at the specified test pressure. Each valve shall have the maker's name or brand, the figure or list number and the guaranteed working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification. All valves shall be the product of one manufacturer except for special applications. Valves shall be Nibco, Hammond, or Fairbanks. Where figure numbers of one manufacturer are stated, equivalent figure numbers can be substituted.

B. Valves shall be of minimum working pressure and materials as fittings specified for the service except as herein modified. All gate and globe valves shall be suitable for repacking under pressure. Regardless of service, valves shall not be designed for less than 125 pounds per square inch steam working pressure.

C. All throttling valves shall have a means of indicating valve position.

2.2 BRONZE GATE VALVES:

A. Screwed Ends, Union Bonnets, Solid Wedge:
   1. Bronze Gates 125 # WSP
      a. Hammond IB631
      b. Nibco T-135
      c. Fairbanks U-0253
      d. Stockham B-105

B. Solder Ends, Screwed Bonnets:
   1. Bronze Gates 125# WSP
      a. Hammond IB648
      b. Nibco S-134
      c. Fairbanks 0282
      d. Stockham B-108

2.3 FLANGED ENDS:

A. Iron Gates 125# WSP
   1. Hammond IR1140
   2. Nibco F-617-0
   3. Fairbanks 0405
   4. Stockham G-623

2.4 CHECK VALVES:

A. Screwed ends, Union Bonnets:
   1. Bronze Checks 125# WSP
      a. Hammond IB944
      b. Nibco T-433-B
      c. Fairbanks 0600
      d. Stockham B-320-TY

B. Solder Ends, Screwed Sonnets:
   1. Bronze Checks 125# WSP
      a. Hammond IB-945
      b. Nibco S-433-B
      c. Fairbanks 0680
      d. Stockham B-309-Y

2.5 FLANGED ENDS:

A. Iron Checks 125# WSP
1. Hammond IR 1124
2. Nibco F-918-B
3. Fairbanks 0702

B. Swing check valves used as vacuum breakers: 15 degrees swing check, composition disc, 150 WSP: Nibco Fig T-433-Y or equal. Valves shall be 3/8" size.

2.6 GLOBE VALVES:

A. Screwed ends, union bonnets (composition or Teflon discs)
1. Bronze Globes 150# WSP
a. Hammond IB413T (2-1/2" IB420)
b. Nibco T-235-Y
c. Fairbanks U-01
d. Stockham B-22-T

B. Solder ends, screwed bonnets (Teflon discs)

2.7 FLANGED ENDS:

A. Iron Globes 125# WSP
1. Hammond IR 116
2. Nibco F-718-B
3. Fairbanks 0131

2.8 BALANCING COCKS:

A. Valves 2" and smaller shall be of bronze body, bronze ball and Teflon seat construction, and rated at 175# and 200 degrees F.

B. Nordstrom Fig. No. 143. Bronze body, square head, tapered plug and washer, lubricated fittings. Provide lubricant and gun, recommended for service intended. Where balancing cocks are indicated, circuits setters may be used.

2.9 CIRCUIT SETTERS:

A. Circuit setters shall include brass balancing cock and taps for taking differential pressure readings. They shall be as manufactured by B&G, Taco, or Armstrong.

2.10 BALL VALVES (2" AND BELOW)

1. Stockham T-395-BR-P-70
2. Nibco T-595
3. Jenkins 1100T

2.11 BUTTERFLY VALVES:

A. Butterfly valves shall have aluminum bronze floating type disc; Buna-N hardback type seat for temperatures up to 170 deg., EPT seat for temperatures over 170 deg., stainless steel dry journal type stems. Bodies shall be wafer and lug type with extended necks adequate for 2" insulation above companion flanges. Operators shall be on-off or infinite throttling lever type in sizes 2" and 6", and gear operators for 8" and above.

B. The valves shall close drop-tight from 24" vac to 150 psi pressure differential.

C. They shall be Demco, Stockham, Monarch, Dover, or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.

B. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward for horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.

C. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive installation.

D. Applications Subject to Shock: Install valves with bodies of metal other than cast iron where thermal or mechanical shock is indicated or can be expected to occur.

E. Applications Subject to Corrosion: Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator. Install bronze valves in steam and condensate service and in other services where corrosion is indicated or can be expected to occur.

F. Mechanical Actuators: Install mechanical actuators with chain operators where indicated, and where valves 4" and larger are mounted more than 8'-0" above floor in mechanical rooms and where recommended by valve manufacturer because of valve size, pressure differential or other operating condition making manual operation difficult.

G. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends or types of pipe/tube connections.

H. Tube Size 2" and Smaller: Soldered-joint valves.

I. Pipe Size 2" and Smaller: One of the following, at Installer's option:
1. Threaded valves
2. Butt-welding valves
3. Socket-welding valves
4. Flanged valves
5. Flangeless valves
6. Single flanges valves

J. Pipe size 2-1/2" and larger: One of the following, at installer's option:
1. Grooved-end valves
2. Butt-welding valves
3. Socket-welding valves
4. Flanged valves
5. Wafer valves
6. Single flange valves

K. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

L. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

M. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

N. Fluid Control: Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.1. Where throttling is indicated or recognized as principal reason for valve, install globe or butterfly valves.

O. Ball valves may be used in lieu of gate valves for equipment shut-off in size 2" and under.

P. Butterfly valves may be used in lieu of gate valves or balancing cocks in water circulating systems in sizes 2" and over. Where valve is for isolation for equipment service, the valve shall be of the lug type.

Q. Valves in positions where unauthorized closing could endanger safety or cause freezeups shall have wrench operation or lock shields and shall be marked with warning signs.

R. Gate valves, globe valves, and strainers shall be a minimum of the pipe size marked on the drawings. Reductions where necessary because of equipment or automatic valve size shall be made with the proper eccentric reducing fittings immediately adjacent to the inlet and outlet of the automatic valve. Bypasses for automatic valves shall be full size of the valve. Provide a service valve on either side of each piece of equipment.

S. Provide a Taco Sentinel pitot tube or a B&G circuit sensor for each balancing cock, or butterfly valve used as a balancing cock, which does not have flow read-out.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section.

B. Rotating and/or reciprocating equipment and associated ductwork and piping shall be vibration isolated in accordance with Section 230548 – Noise and Vibration Control for Mechanical Systems

1.2 SUMMARY

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

1.3 DEFINITIONS

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

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

1.4 PERFORMANCE REQUIREMENTS

A. Pipe hangers and equipment supports provided by Division 23 Contractor.

1.5 SUBMITTALS

A. Submit welding certificates.

B. Provide all product data for all support types.

C. Shop Drawings: Seismic restraints shall be signed and sealed by a professional engineer.

1.6 QUALITY ASSURANCE

A. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. ASME Boiler and Pressure Vessel Code.

1.7 COMPONENTS

A. Metal Pipe Hangers and Supports: Hot-dipped, galvanized steel and copper.

B. Trapeze pipe hangers.

C. Metal Framing Systems: MFMA manufacturer.

D. Thermal-hanger shield inserts.

E. Fastener Systems: Powder-actuated fasteners and mechanical-expansion anchors.

F. Pipe Stands: Curb-mounted type.

G. Equipment supports.

PART 2 - PRODUCTS

2.1 PIPE HANGERS, SUPPORTS AND ANCHORS:

A. All bracket, clamp and rod sizes indicated in this Specification are minimum sizes only. The installing trade shall be responsible for structural integrity of all supports. All structural hanging materials except variable spring units shall have a safety factory of 5 built in.

B. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS Standards.

C. All hangers on piping including clevis hangers, inserts, clamps, stanchions, brackets, shall be dipped in zinc chromate primer before installation or shall be galvanized. Rods shall be galvanized.

2.2 MANUFACTURERS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:
1. Anvil International
2. B-Line Systems, Inc.; a division of Cooper Industries
3. Carpenter & Paterson, Inc.

4. ERICO/Michigan Hanger Co.; ERISTRUT Div.
5. GS Metals Corp.
6. National Pipe Hanger Corporation

C. Galvanized, Metallic Coatings: Hot dipped.

D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE HANGERS

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

B. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

2.4 THERMAL-HANGER SHIELD INSERTS (Provide for all hot, condenser water and chilled water piping)

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Insulation-Insert Material for Hot and Condensing Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552 or Type II cellular glass

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

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

E. Insert Length: Extend 2 inches beyond sheet metal shield.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

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

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

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89 for the installation of hangers, supports, clamps, and attachments to properly support piping from building structure.

B. Hanger Spacing:
1. Hanger spacing and sizing shall be per MSS SP-69 or applicable codes, whichever is more stringent.
2. Hanger spacing shall be reduced to compensate for any valves and/or fittings installed in the pipe run.
3. Alternate span calculations may be used with a maximum deflection of 0.1 inch between hangers.
4. Hanger spacing shall be reduced if thermal hanger shield insert cannot support full span.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.3.1.

3.3 PREPARATION

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

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.4 INSTALLATION OF BUILDING ATTACHMENTS

A. Install building attachments at required locations, within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping, ductwork or other supported mechanical or electrical items.

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

C. Support fire-water piping independently of other piping.

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

E. Provisions for Movement: Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

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

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 are not exceeded.

H. Insulated Piping: Comply with the following installation requirements.
   1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.
   2. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on chilled water piping, install coated protective shields. For pipe 8" and over, install wood insulation saddles.

END OF SECTION 230529

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SECTION 230548 - NOISE AND VIBRATION CONTROL FOR MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide complete noise and vibration control systems as shown or specified and in accordance with the requirements of the Contract Documents. System shall be complete with:
   1. Foundations and supports for rigidly supported equipment.
   2. Vibration Isolation Equipment
   3. Fan and Duct System Acoustic Plenums
   4. Sealing Around Services Penetrations Through Walls and Slabs

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Consult all other Sections to determine the extent of work specified elsewhere but related to this Section. This work shall be properly coordinated to produce an installation satisfactory to the Owner. This work includes, but is not limited to the following:
   1. Air Handling Units
   2. Ductwork
   3. Duct Insulation (External)
   4. Internal (Acoustical) Duct Liner
   5. Pumps
   6. Piping
   7. Heating and Cooling Equipment
   8. Concrete Housekeeping Pads / Inertia Bases
   9. Sealant

1.3 CONTRACTOR'S RESPONSIBILITY

A. The HVAC Contractor shall be responsible for verifying the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this specification. The HVAC Contractor, even if not specifically mentioned herein or in the Contract Documents, shall supply any additional equipment needed to meet the intent of this specification, without claim for additional payment.

B. Performance or waiving of inspection, testing or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly to the Contract Documents. The HVAC Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architects to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.

C. The intent of the designers is that there are no conflicts between this and other sections of the specification. If conflicts are discovered between this section and any other section or subsection of 23, it shall be the HVAC contractor’s responsibility to immediately bring this fact to the architect’s

attention and request instruction. Absent that instruction, the contractor shall assume that this current section shall overrule in any conflicts.

1.4 MANUFACTURER'S RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:
   1. Provide piping and equipment isolation systems as scheduled or specified.
   2. Guarantee specified isolation system deflection.
   3. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
   4. The vibration isolation systems shall be guaranteed to have deflection indicated on the schedule on the drawings. The mounting manufacturer shall determine mounting sizes and the sizes shall be installed in accordance with the manufacturer's instructions.
   5. The vibration isolator vendor shall ensure that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators. Where additional support structure is required, vibration isolator vendor shall provide this.

1.5 BID PROPOSALS

A. The HVAC Contractor shall submit at the time of bidding the names and qualifications of the noise and vibration control supplier(s). If a supplier is not one of the pre-approved vendors, then the submittal shall be accompanied by a complete catalog of that supplier's products and samples of each proposed vibration isolator.

B. If the standard sizes of attenuators offered by the supplier do not provide attenuation equal to or greater than the insertion loss specified in each octave band 1 through 5, then at the time of bidding the supplier shall note all such discrepancies and propose a method for producing the difference within the bid and without affecting the project construction schedule. The controlling requirements are the insertion loss, pressure drop and self-noise.

1.6 SUBMITTALS

A. The HVAC contractor shall submit fully coordinated shop drawings for all vibration and noise control equipment. These submittals shall state the acoustical performance of the products as described below.
   1. Sheet Metal: Coordinated shop drawings at 1/4” = 1’ -0” minimum scale shall be submitted for review and approval to indicate the following:
      a. Length, width, height and elevation of bottom of each duct segment
      b. Clearly indicated locations of duct silencers, fire dampers, combination fire/smoke dampers and balancing dampers
      c. Transition segments marked with entrance and exit sizes, as well as length and elevation
      d. Indication of duct offsets in the horizontal or vertical direction
      e. Duct lining thickness, including, if it changes, where it changes

2. Isolators: Submittal to the Architect shall include drawings prepared by the isolation materials manufacturer showing the construction of the isolation devices to be used, including specific selection of isolators for the equipment to be furnished for this project.
3. Submittal of vibration isolation system schedule indicating the following:
   a. Manufacturer, type, model number, size
   b. Height when uncompressed and static deflection of each isolation element
   c. Spring constant of each isolation element
   d. Estimated imposed load on each isolation element
   e. Spring o. d., free operating and solid heights
   f. Design of supplementary bases, if any
   g. Layout of isolator hangers, mounts and other elements shown on an outline of the isolated equipment, including complete details of attachment to load-bearing structure or supplementary framing
   h. Piping isolators shown and identified on piping layout drawing
   i. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by mechanical contractor and shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports and all required hanger bolts and other accessories necessary for the proper installation of his equipment. All concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade and drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

1.7 SEALING OF PENETRATIONS

A. Building structures meant to isolate air-borne noise surround the noise critical spaces and spaces that contain noise, i.e. mechanical equipment rooms. These building structures must be massive, airtight constructions. The effectiveness of sound isolating structures can be severely compromised by penetrations for ductwork and piping. Proper sealing and/or lagging (enclosure) around mechanical services penetrating these structures will maintain the integrity of the isolating structure.

B. Foam Rod - Foam Rod is used to seal around duct penetrations as they pass through block work or concrete.

C. Non-Hardening Sealant - Non-Hardening Sealant is used to seal the Foam Rod to the ducts and to the construction through which the ducts penetrate.

1.8 QUALITY ASSURANCE

A. It is the objective of this Specification to provide for the control of noise and vibration due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

B. A single manufacturer shall provide all vibration isolation equipment and materials. The following manufacturers are approved provided systems are in compliance with the specified design and performance requirements. The project acoustics consultant must approve any others.
   1. Mason Industries, Inc., Hauppauge, New York
   2. Amber Booth, Houston, Texas
   3. Kinetics Noise Control, Dublin, Ohio

C. A single manufacturer with a minimum five years experience shall furnish all prefabricated attenuators. The following manufacturers are approved provided equipment is in compliance with the specified design and performance requirements. The project acoustics consultant must approve any others.
   1. Industrial Acoustics Company, Bronx, New York (IAC)
   2. Vibron
   3. Vibro-Acoustics
   4. United Sheet Metal
   5. Semco

D. The following duct liner manufacturers are approved, provided the product is in compliance with the specified design and performance requirements. The project acoustics consultant must approve any others.
   1. Certainteed
   2. Owens-Corning
   3. Knauff

PART 2 - PRODUCTS

2.1 GENERAL

A. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.

2.2 INTERNAL ACOUSTICAL DUCT LINING

A. Duct liner shall comply with the requirement of NFPA 90A and the “Duct Liner Materials Standard” of the Thermal Insulation Manufacturer’s Association.

B. Sizes shown on the drawings are sheet metal clear dimensions (after installation of duct liner).

C. All acoustical duct lining shall incorporate means to prevent fiber entrainment in the air stream.

D. Duct lining shall be 1” thick and have minimum density of 3.0 pcf.

E. Plenum lining shall be 1” thick and have minimum density of 3.0 pcf.

2.3 FOAM ROD

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

2.4 NON-HARDENING SEALANT

A. Sealant for penetrations shall be non-hardening polysulphide type.

B. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

2.5 PACKING MATERIAL FOR PENETRATIONS

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

2.6 FIRE DAMPERS:

A. Fire dampers shall be a type with the blade stored out of the air stream.

2.7 FLEXIBLE DUCT CONNECTORS

A. Flexible sleeves for duct connections shall be fabricated from flexible, airtight, flame-retarded or noncombustible fabrics, coating and adhesives complying with UL Standard 181 Class 1.

B. Extra-Wide Metal-Edged Connectors: Factory-fabricated with a strip of fabric 5-3/4 inches wide attached to 2 strips of 2-3/4" wide, 24-gauge galvanized sheet steel or 0.032-gauge aluminum sheets. Select metal compatible with connected duct system. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA HVAC Duct Standard, 1 st Edition, Figure 2-19.
   1. Fabric: Glass fabric double coated with polychloroprene.
   2. Minimum Weight: 26 oz per square yard
   3. Tensile Strength: 480 lb/in in the wrap and 360 lb/in in the filling.

2.8 ATTENUATORS:

A. Rectangular attenuators shall have outer casings of not less than 22 gauge galvanized steel. Seams shall be lock formed and mastic filled. The internal baffles (splitters) shall be not less than 24 gauge galvanized perforated steel having an open area of about 30%. The nosings shall be full radius or airfoil shape.

B. The sound absorbing media shall be not less than 4.5 pcf glass/mineral fiber packed under 5% compression. The fiberfill shall be incombustible, mildew resistant and vermin proof. The sound absorbing material shall be protected from erosion.

C. If the attenuator is supplied in modular sections, the attenuator shall meet or exceed the specification for single-module attenuators with respect to insertion loss, pressure drop, regenerated noise and air leakage.

2.9 VIBRATION ISOLATION SYSTEMS

A. The static deflection of isolators shall be as given in the equipment schedule and specified below. The isolator schedule shall take precedence.

1. The vibration isolator supplier shall determine vibration isolator sizes and layout.
2. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.
3. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.
4. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10%.
5. All neoprene mountings shall have a Shore hardness of 30 to 60 ±5, or as specified herein, after minimum aging of 20 days or corresponding over-aging.
6. Housed or caged spring isolators are not acceptable.
7. Where steel spring isolation systems are described in the specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.
8. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

B. ISOLATOR TYPE DDNH
1. Type DDNH (Double Deflection Neoprene Hangers) shall consist of a molded neoprene isolating element in a steel hanger box. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 3/4 inch larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30 degree arc. When installed, the hanger box shall be allowed to rotate through a full 360 degrees without encountering any obstructions.
2. The isolator shall be manufactured with bridge bearing quality neoprene and selected for a maximum durometer of 50 and designed for 15% strain. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3 inches.
3. (Type DDNH: Mason Industries Type HD or as approved.)

C. ISOLATOR TYPE RBA
1. Type RBA isolators shall be designed with a neoprene element to provide isolation in tension, shear or compression. Neoprene to bridge bearing quality with a maximum durometer of 50.
2. (Type RBA: Mason Industries Type RBA or as approved)

D. ISOLATOR TYPE SPNM
1. Type SPNM (Spring and Neoprene Mounts) shall have a free-standing and laterally stable steel spring without any housing. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall be not less than 80% of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50% of the specified static deflection.
2. Unless otherwise specified, the minimum static deflection of SPNM isolators for equipment mounted on grade slabs shall be 1 inch and the minimum static deflection for equipment mounted above grade level shall be 2 inches.
3. Two Type WP isolation pads sandwiching a 16 gauge stainless or galvanized steel separator plate shall be bonded to the isolator baseplate.
4. Unless otherwise specified, isolators need not be bolted to the floor for indoor installations. If the base plates are bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
5. (Type SPNM: Mason Industries Type SLFSW or as approved.)

E. ISOLATOR TYPE SPNH
1. Type SPNH (Spring & Neoprene Hangers) shall consist of a steel spring in series with a neoprene element. The spring shall have a minimum additional travel to solid equal to 50% of specified deflection. Neoprene element shall have static deflection of not less than 0.3” with a strain not exceeding 15%.
2. Unless otherwise specified, the static deflection of SPNH hangers shall be 2”.
3. Spring diameter and hanger box hole size shall be large enough to permit the hanger rod to swing through a 30 degree arc. A neoprene sleeve shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 3/4 inch larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked and the hanger box shall be allowed to rotate through a full 360 degree arc without encountering any obstructions.
4. (Type SPNH: Mason Industries Type 30N or as approved.)

F. ISOLATOR TYPE CSNM
1. Type CSNM (Constrained Spring and Neoprene Mounts) shall be a spring and neoprene mount that incorporates a housing which incorporates unrestrained stable springs with built-in leveling device and resilient vertical limit stops to prevent spring elongation when partial load is removed and limits the movement of equipment when it is subjected to wind loading.
2. A minimum clearance of 1 inch shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring operation. Limit stops shall provide minimum 1/4” clearance under normal operation and a neoprene washer shall be installed beneath the bolt head/washer used to restrain the isolator.
3. In installations subject to wind load, provide tapped hole in top and bottom plates for bolting to equipment and the roof or supporting structure with a neoprene mounting sleeve.
4. Provide minimum 1/4” inch thick neoprene acoustical base pad on underside of mount unless designated otherwise.
5. Mount shall be capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
6. Unless otherwise specified, the minimum static deflection for Type CSNM mounts shall be 2 inches.

7. (Type CSNM: Mason Industries Type SLR or as approved)

G. BASE TYPE CB
1. Inertia base Type CB (Concrete Base) shall have an integral rectangular structural steel form into which concrete is poured.
2. Perimeter members shall be beams of depth equal to 10% of the longest span of the base, but not more than 12 inches nor less than 6 inches deep. Forms shall include motor slide base and all reinforcing steel. Where anchor bolt locations fall in concrete, the reinforcing steel shall include drilled members with sleeves welded below the steel to accept the anchor bolts. Height saving steel brackets shall be used in all mounting locations.
3. When the concrete base is "T" shaped, isolators shall be located under the projections as well as under the main body in order to prevent cantilever distortion.
4. The structural perimeter frame, mounting templates, height saving brackets and spring system shall be provided as an assembly by the vibration control vendor.
5. (Base Type CB: Mason Industries Type KSLFSW or as approved)

2.10 PIPE FLEXIBLE CONNECTORS

A. Flexible connectors for pipes shall be neoprene Mason Type MFNEC, MFTNC or as approved. Do not use control rods.

PART 3 - EXECUTION

3.1 GENERAL

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All floor-mounted equipment shall be erected on 4" thick concrete housekeeping pads over the complete floor area of the equipment, unless otherwise specified to the contrary herein. These pads shall be integrally keyed to structural slab. Wherever vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted on concrete housekeeping pads unless otherwise specified to the contrary herein.

C. Furnish and install neoprene mounting sleeves for hold-down bolts to prevent any metal to metal contact.

D. All equipment shall be provided with lateral restraining isolators as required to limit horizontal motion to 1/4" maximum, under all operating conditions. Lateral restraining isolators shall have the same static deflection as equipment being isolated.

E. Unless otherwise indicated, all equipment mounted on vibration isolators shall have a minimum operating clearance of 2 inches between the bottom of the equipment or inertia base (and height-saving bracket) and the concrete housekeeping pad (or bolt heads) beneath the equipment. The clearance shall be checked by the Contractor to ensure that no material has been left to short- circuit the vibration isolators. There shall be a minimum 4 inch clearance between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.

F. Piping, ductwork, conduit or mechanical equipment shall be supported from building structure, not hung from or supported on other equipment, pipes, or ductwork.

G. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping and blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims.

H. All mechanical equipment not specifically identified in this specification that contains rotating or vibrating elements and any associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or RBA neoprene isolators as appropriate.

I. All wiring connections to mechanical equipment on isolators shall be made with a minimum 36 inch long flexible conduit in a 360 degree loop.

J. Springs shall be designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.

K. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

L. Refer to Vibration Isolation Schedule at the end of this Section.

3.2 FAN ISOLATION - GENERAL

A. Fans shall be mounted on vibration isolators as described herein, as shown on the equipment schedule and on the drawings.

B. Fans and air handling units shall be leveled with the fans operating before the flexible connectors are attached.

C. All fan bases and isolators shall be sized so that thrust restraints (which would act against turning moment caused by static pressure) are not required.

3.3 MOUNTING OF FLOOR MOUNTED PACKAGED AIR HANDLING UNITS

A. This equipment shall be mounted directly on concrete pad with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, no additional structural frame shall be installed beneath the unit. The motor and fan shall be integrally mounted on slide rails with spring isolators.

B. Minimum static deflection shall be 2" unless scheduled otherwise.

C. All connections to be flexible.

D. Drain pipes for air-handling units shall be supported only from the isolated air handling unit frame. The condensate shall drip into a funnel that is supported from the floor or floor drain. A gap of at

least 2 inches shall be maintained between the end of the air handling unit drain pipe and funnel or floor drain.

3.4 MOUNTING OF CENTRIFUGAL PUMPS:

A. Each pump with its driving motor shall be bolted and grouted to a spring supported concrete inertia base reinforced as required.

B. Each concrete base (rectangular or "T" shape) for horizontally split pumps shall include supports and base elbows for the suction and discharge connections. Base elbows shall be bolted and grouted to the concrete foundation.

C. Concrete inertia base thickness shall be in accordance with the following schedule and be provided with a 2" minimum operating clearance between the base and housekeeping pads.

D. All connections to be flexible.

E. Minimum Inertia Block: Thickness 6”

F. Vibration Isolator Type shall be Type CB.

3.5 SUPPORT OF PIPING

A. The following piping shall be resiliently supported:
1. All piping in equipment rooms.
2. Piping outside of equipment room within 40 feet of connected rotating equipment
3. All piping in shafts.

B. Resilient diagonal mountings or other approved devices shall be provided as required to limit piping motion due to equipment startup or shut down, to a maximum of 1/8".

C. Water piping hanger rod isolators shall contain a steel spring in series with a 1/4" acoustical neoprene pad within a steel box retainer. The hanger rod isolator assembly shall be rigidly supported from the spring sub assembly shall not contact the steel box retainer and clearances in the isolator design shall be capable of accepting a 15 degree misalignment in any direction from the vertical.

D. The steel spring element of the assembly shall be designed to have a minimum deflection of 3/4".

E. Where supplementary steel is required to support piping, the supplementary steel shall be sized so that maximum deflection between supports does not exceed 0.08" and shall be resiliently supported from the building structure with mountings as described above. Supported piping from the supplementary steel shall be rigidly suspended or supported.

F. Where isolated water piping 8" and larger is supported directly below exposed steel beams, attachment to the beam shall be made by means of welded channel beam attachments located directly under the web of the beam. For piping 6" and smaller beam clamps may be used in lieu of welding subject to approval of beam clamp selection.

3.6 SUPPORTS

A. Piping supports within shafts shall be provided with suitable bearing plates and two layers 1/4" thick ribbed or waffled neoprene pad loaded for 50 psi maximum. The isolation pads shall be separated with 1/4" steel plate.

B. The isolation pads shall be Mason Industries Type W or approved equal.

C. Piping isolation supports at the base of risers shall be two layers of 1/2" thick heavy duty neoprene and canvas duct isolation pad separated by 1/4" thick steel plate. Suitable bearing plates sized to provide a pad loading of 500 psi maximum shall be provided. The stanchion between the pipe and isolation support shall be welded to the pipe and welded or bolted to the isolation support. The isolation support shall be bolted to the floor slab with resilient sleeves and washers.

D. All pipe support resilient materials shall be HL Mason Industries, Inc., or as approved.

3.7 DUCT SUPPORTS

A. Ducts in mechanical rooms shall be supported by neoprene hangers, Type DDNH.

B. Ducts beyond 25 feet of mechanical rooms shall be rigidly supported.

3.8 PIPES CONNECTED TO EQUIPMENT ON SPRING ISOLATORS

A. All pipes connected to equipment installed on spring vibration isolators, shall be suspended or, supported by Type SPNM or Type SPNH isolators.

B. The first isolator both upstream and downstream of equipment on springs shall have a static deflection equal to 1.5 times that of the equipment isolators, up to a maximum of 2 inches. The static deflection of the remaining pipe isolators shall be 1 inch.

3.9 FLEXIBLE PIPING CONNECTORS

A. Flexible piping connectors shall be installed to connect piping diameter 2” or greater to reciprocating or rotating equipment.

3.10 PIPE RISERS

A. Where pipes rise in a vertical chase and are supported from a structure with type SPNH or DDNH isolators and require lateral bracing, neoprene riser guides shall be mounted around the pipe to limit lateral movement and to prevent direct contact with the supporting structure.

3.11 DUCT ISOLATION

A. Ducts shall be connected to fans, fan casings and plenums by means of flexible connectors. Flexible connectors shall be installed to prevent metal-to-metal contact across flexible connection. Flexible duct connectors shall not be used outside the mechanical room unless expressly shown on the drawings.

3.12 DUCTWORK FABRICATION

A. Fabricate ductwork so as to be free from vibration, rattle or drumming under all operating conditions; provide all materials necessary for specified construction, whether or not they are specifically called for or detailed on the drawings.

3.13 BRACING OF DUCTWORK

A. Install tie rods within ducts as required.

3.14 ACOUSTICAL LINING OF DUCTS

A. Ducts where noted, shall be acoustically lined internally. Both supply and return systems shall be lined where shown.

B. Acoustical duct lining shall be 1inch thick in ducts and where shown on the drawings.

C. The acoustical liner shall be fixed to the duct with a minimum of 50% coverage of a fire-resistant adhesive. Where the duct width exceeds 12 inches or the height 24 inches, the liner shall be additionally secured with mechanical fastening on maximum 16 inch centers on all sides. Mechanical fasteners that pierce the duct are unacceptable. All ends of the liner shall be coated with a fire resistant cementing material to prevent delamination, leakage or erosion. All joints shall be firmly butted and ends coated with an adhesive to ensure that the lining is smooth across all joints.

D. Where acoustical duct lining is installed, the dimensions shown on the mechanical drawings are the clear interior dimensions after the liner has been installed.

3.15 LINING OF ACOUSTICAL PLENUMS

A. Unless otherwise specified, acoustical plenums shall be lined with 1 inch thick glass or mineral fiber duct liner of at least 3-lb density.

3.16 SHEET METAL AND PIPING PENETRATIONS OF SHAFTS, FLOOR SLAB AND/OR PARTITIONS

A. There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partition.

B. All openings around pipes and ducts in the structure surrounding the mechanical equipment and surrounding spaces shall be sealed packed with caulking for the full depth of the penetration, as described herein and as shown on the drawings. This includes all slab penetrations and penetrations of walls.

3.17 DUCT PENETRATIONS

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

3.18 PIPE PENETRATIONS

A. HVAC PIPING: Where a pipe passes through a wall, ceiling or floor slab, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be 2 inches larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, the Contractor shall check the clearance and correct it, if necessary, to within 1/2 inch. Then the void shall be packed full depth with glass /mineral fiber and sealed at both ends, 1 inch deep, with sealant backed by foam rod.

B. DAMPERS:
1. Dampers shall be installed only where shown on the drawings.
2. Combination dampers shall be installed where specifically called out on the drawings

C. WIRING: All wiring connections to mechanical equipment on vibration isolators (either spring or neoprene type) shall be made with a minimum 36 inch (1m) long flexible conduit in a 360 degree loop. This Contractor shall coordinate wiring connections with the Electrical Contractor.

D. FIELD QUALITY: HVAC Contractor shall work in accord with best trade practices, shall fabricate and install all items in accordance with manufacturer's recommendations and Architect's directions and shall consult with trades doing adjoining work in order to provide an installation of first class quality.

3.19 VIBRATION ISOLATION SCHEDULE FOR MECHANICAL EQUIPMENT

EQUIPMENT	BASE TYPE	ISOLATOR TYPE	STATIC DEFLECTION
Floor Mounted AHU's	4" Housekeeping Pad	SPNM	2" Internal
Base-mounted pumps	Inertia Base	SPNM	2"
Piping		Isolation as per specification	1"

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. DUCT INSULATION.
2. HVAC PIPING INSULATION
3. VARIABLE FREQUENCY MOTOR CONTROL
4. HYDRONIC PUMPS
5. HEAT EXCHANGERS FOR HVAC
6. DEDICATED OUTDOOR-AIR UNITS
7. WATER-SOURCE UNITARY HEAT PUMPS
8. WATER-TO-WATER HEAT PUMP

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide and install on each valve 1” in size or greater for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.

B. Provide typewritten valve charts indicating each valve identifier, the valves service, normal position and its location. Also furnish one electronic copy on CD in “*.xls” format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.

C. All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e. main HVAC valves, etc.).

D. Label all control panels and disconnect switches with service and equipment served.

PART 3 - EXECUTION

3.1 PIPING AND DUCTWORK IDENTIFICATION:

A. All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.

B. The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

OUTSIDE DIAMETER	LABEL LENGTH	LETTER SIZE
¾" – 1 ¼"	8"	½"
1 ½" – 2"	8"	¾"
2 ½" – 6"	12"	1 ¼"
8" – 10"	24"	2 ½"

C. The following chart describes the pipe service and label identification which shall be used for various pipes.

PIPE	ABBREVIATION
Geothermal Supply	G.S.
Geothermal Return	G.R.
Dual Temp Water Supply	D.T.S.
Dual Temp Water Return	D.T.R.
Refrigerant Piping	RF
Condensate	C.D.
Domestic Cold Water	D.C.W.
Domestic Hot Water	D.H.W.
Recirculated Hot Water	R.H.W.
Natural Gas	NAT.GAS.
Fire Protection	SPRINKLER

PIPE	ABBREVIATION
Sanitary Sewer Piping	SAN
Sanitary Vent Piping	VENT
Storm Sewer Piping	STORM

D. All ductwork shall be identified as to the service of the duct and direction of flow. Include equipment designator on SA & RA ductwork. The letters shall be at least two inches high, and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Concealed ducts also need to be identified.

DUCTWORK	ABBREVIATION
Supply Air Ductwork	SA + Equipment Identifier
Return Air Ductwork	RA + Equipment Identifier
Exhaust Air Ductwork	EA + Equipment Identifier
Outside Air Ductwork	OA + Equipment Identifier
Transfer Air Ductwork	TA + Equipment Identifier

3.2 EQUIPMENT IDENTIFICATION

A. Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise, and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1” high white letters on the front of each piece of equipment.

B. All mechanical equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

C. All insulated and uninsulated piping in geothermal mechanical room, shall be completely painted by this contractor.

D. All piping shall be painted in accordance with the following color coding chart. Verify colors with the Owner prior to painting. Paint all pipes evenly in a workmanlike manner. Apply a minimum of two coats of paint for sufficient coverage.

PIPE	PIPE COLOR CODE	ABBREVIATION
Chilled water supply	Blue pipe with white letters	CHWS
Chilled water return	Blue pipe with white letters	CHWR
Hot water supply	Red with white letters	HWS

PIPE	PIPE COLOR CODE	ABBREVIATION
Hot water return	Red with white letters	HWR
Domestic Cold Water	Blue w/White Letters	D.C.W.
Domestic Hot Water	Brown w/White Letters	D.H.W.
Fire Protection	Red w/White Letters	SPRINKLER
Sanitary Sewer Piping	Grey With No Letters	
Sanitary Vent Piping	Grey With No Letters	
Storm Sewer Piping	Grey With No Letters	

* Include pumps, air separator, valves, etc.

E. Water heaters, storage tanks, heat exchangers, etc. shall be painted light gray.

F. Where a pipe is not specifically identified in this table, painting and marking shall be in accordance with the most recent ANSI Standards. Verify with Engineer.

3.3 ACCESS THROUGH LAY-IN CEILINGS:

A. Mark each lay-in ceiling panel which is nearest access to equipment, valves, dampers, filters, duct heaters, etc., with colored tape labels located on the ceiling grid.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. METERS AND GAGES FOR HVAC PIPING
3. INSTRUMENTATION AND CONTROL FOR HVAC
4. FACILITY MONITORING SYSTEM
5. VARIABLE FREQUENCY MOTOR CONTROL
6. HYDRONIC PUMPS
7. METAL DUCTS
8. AIR HANDLING UNITS
9. VAV BOXES
10. FANS
11. SPLIT SYSTEMS

1.2 SCOPE OF WORK

A. The Engineer, or authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these Specifications or required by others.

B. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow the work to be furred in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

C. The test and balance of this system shall be by a Contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services.

D. The test and balance contractor shall bid directly to the HVAC Contractor or Construction Manager or Owner.

E. For the purpose of placing the Heating, Ventilating and Air Conditioning systems in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Total System Balance, Volume Six (2002), for air and hydronic systems as published by the Associated Air Balance Council.

F. Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

PART 2 - PRODUCTS: (NOT USED)

PART 3 - EXECUTION

3.1 SYSTEMS TO BE TESTED AND BALANCED:

A. The supply, return, outside and exhaust air duct systems associated with all DOAS and heat pump units. Provide static pressure profiles thru DOAS systems. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the heat pump unit. Show accurate representation of outdoor and exhaust air damper locations. Record coil and unit discharge temperatures.

B. Toilet exhaust air in each room to within 10% of design air flow rate.

C. Verify calibrations of the duct static pressure and water pressure sensors for all systems.

D. Balance all supply and outside, exhaust and return air grilles to within 10% of design air flow rate.

E. Balance all specialty exhaust systems indicated on plans including, but not limited to, labs, auto, welding, and kiln.

F. Balance all hydronic pumps and coils. Record temperatures and pressures at each.

G. Balance all kitchen exhaust and associated make-up air units.

H. Each DOAS shall have supply and return duct air leakage testing per Specification Section METAL DUCTS. Coordinate with sheet metal contractor.

I. Balance the domestic hot water recirculation pump and associated balancing valves of each domestic water heating system.section

3.2 REPORTS AND DOCUMENTS

A. Three (3) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.

B. HVAC Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.

3.3 COORDINATION AND TESTING

A. The HVAC Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test as specified and shall be proven tight after a twenty-four (24) hour test.

B. All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating, and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.

C. System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

D. Testing shall occur after completion of the ceiling systems installation.

E. All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.

F. Provide a preliminary test report to the Engineer immediately after the system is air balanced, or any initial phases are balanced. This report may be handwritten. Any systems that are not found to operate within the design tolerances by the Test and Balance Contractor shall immediately be reported to the Engineer via telephone call to attempt to determine a resolution while the Test and Balance Contractor is still on site. Additional compensation will not be accepted for additional trips.

G. Anticipate visiting the site again after the Engineer has reviewed the report. The Engineer may request up to two (2) additional site visits for onsite troubleshooting where additional measurements may be required.

H. Balance all units rated for 2,000 cfm unit such that the total air volume delivered does not exceed 2,000 cfm, otherwise the Contractor shall furnish and install a code compliant duct smoke detection system integrated into the building’s system.

I. Test and Balance agency shall provide sizing of fan or motor sheaves required for proper balance. The Mechanical Contractor shall purchase and install all sheaves and belts as required. This includes new and existing equipment.

J. The Contractor shall provide and coordinate work to provide sufficient time before final completion date so that tests and balancing can be accomplished and provide immediate labor and tools to make corrections when required without undue delay.

K. The Contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

L. The Test and Balance Contractor shall be present during the Engineer’s final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

END OF SECTION 230593

SECTION 230595 - SYSTEM TESTING, CLEANING & START-UP

PART 1 - GENERAL

1.1 SCOPE:

A. This work includes cleaning the various air and water systems, pressure testing to ensure tightness, and start-up of the various systems to prove their operational capability.

PART 2 - PRODUCTS

2.1 GENERAL

A. This contractor shall provide all water and other materials used for testing.

PART 3 - EXECUTION

3.1 TESTING SYSTEMS:

A. Pipe pressure testing: Prior to testing, remove or otherwise protect from damage all control devices, trap bellows, air vents, or other devices not designed to withstand the test pressure.

B. Piping Pressure Tests: The following system shall be hydrostatically tested at a pressure of 1-1/2 times the normal working pressure, or 125 psi, whichever is greater:

1. Chilled and Hot Water Piping
2. Equipment Vents

C. All work must remain uncovered until required tests have been completed but in the event that the project construction schedule required it, this contractor shall make arrangements for prior tests on portions of the work involved. All costs of these tests shall be paid by this contractor. Any damage caused as a result of tests shall be repaired at the expense of this contractor.

D. It is desirable that each system be tested in its entirety, but the various systems may be tested in sections as may be required to expedite the work of other trades.

E. Test pressure shall be maintained without pumping for a minimum of 4 hours without loss of pressure other than may be attributable to changes in atmospheric conditions. Sweats or drips will not be accepted.

F. After satisfactory completion of tests and before permanently connecting equipment, traps, strainers, etc. flush entire pipe systems for sufficient length of time to free interiors completely of foreign matter.

3.2 LEAKAGE TESTING FOR MEDIUM PRESSURE DUCT SYSTEM:

A. The installed medium pressure duct system shall be tested at 4" WC pressure.

B. The air leakage at the test pressure shall be measured by a calibrated orifice type of flow meter. Total allowable leakage of the system shall not exceed 1% of the air handling capacity of the system.

C. If the system is tested in sections, the leakage rates shall be added to give the performance of the whole system.

D. Leakage concentrated at one point may result in objectionable noise even if the system passes the leakage rate criteria. This noise source must be corrected to the satisfaction of the Engineer.

E. The orifice of flow measurement device must have been individually calibrated against a primary standard, and this calibrated curve permanently attached to the orifice tube assembly.

F. Testing must be in accordance with a printed procedure submitted to the Engineer for approval.

3.3 TESTS FOR LOW PRESSURE DUCT:

A. All low pressure supply, return and exhaust duct, plenums, casings shall be tested and made airtight before covering or concealing. Supply duct, plenums, and casings shall be tested under 2" WC positive pressure. Return and exhaust ducts and casings shall be tested under 2 inch WC positive pressure.

B. Tests shall be made before insulation is applied to joints, fittings, or valves. The A/E representative shall be given the opportunity to observe all tests and items under test shall not be covered up until after the A/E representative has observed the test or has been given a letter waiving the right of observation of the test.

C. Total allowable leakage of the system shall not exceed 2% of the air handling capacity of the system.

3.4 CLEANING OF SYSTEMS:

A. The inside of the air terminal units, ducts, plenums, and casings shall be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, duct, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building and the ducts, plenums; casings, and other items specified hereinbefore have been vacuum cleaned. It shall be the responsibility of this contractor to maintain the system in this clean condition until final acceptance.

B. Clean all piping systems, equipment, and accessories (especially pumps, valves, flange faces, gauges, etc.) of cutting chips and foreign matter while installing.

C. Cleaning of piping systems shall be as described under Chemical Treatment.

D. Temporary bypasses shall be provided for all water coils to prevent flushing water from passing through coils.

3.5 GENERAL:

A. Be careful to provide all sight glasses, control valves, pumps, and any items that could be damaged by foreign material with 40 mesh screen on the inlet side, or bypass, or remove such items.

B. Clean out the strainers, and all low velocity areas where dirt accumulated.

C. Protect all water systems from freezing.

D. Clean all strainers and dirt legs.

3.6 START-UP AND TEST:

A. Each system shall be started up and a preliminary test made as follows:

1. This contractor shall make trail runs of each piece of equipment furnished by him. This contractor shall provide all oil, grease, and other lubricants for the operation of all equipment until acceptance. This contractor shall be held responsible for all damage to bearings while the equipment is being operated by him up-to-date of acceptance of the equipment, and for a period thereafter as per the general building warranty. The contractor shall be required to protect all bearings during installation and shall thoroughly grease steel shafts to prevent corrosion.

2. The contractor shall align each shaft and adjust all pulleys to run substantially vibration-free. Where equipment cannot be so adjusted by the contractor, the manufacturer shall provide a machinist or serviceman to make these adjustments. Vibration-free is construed to mean that rotating machinery shall not exceed a self-excited vibration velocity of 0.10 inches per second in any direction when measured with a vibration meter on the bearing caps of the machine.

3. Belts shall be checked for alignment and tightened to proper tension.

4. Overload elements in motor starts shall be checked and proper elements provided as required for the motor full load amp rating.

5. Glands, seals, etc. shall be examined and properly adjusted.

6. Air vents shall be bled.

7. Equipment shall be started per manufacturer's instructions and run in.

8. Read amperage and voltage on each motor the first time it is started, and check direction of rotation.

9. Run an operating test on each piece of equipment. The tests shall be sufficient to show that the equipment has been run and observed and shall include the following:

10. Each fan amp. draw and discharge static pressure.

11. Temperature of air entering and leaving each coil in air handling unit.

12. Pressure drop across each filter bank service other than individual rooms.

13. Volts and amps on each motor.

14. Results of preliminary tests shall be submitted before test and balance sub-contractor commences his work.

END OF SECTION 230595

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
3. METAL DUCTS
4. AIR DUCT ACCESSORIES
5. DIFFUSERS, REGISTERS & GRILLES

1.2 SCOPE OF WORK

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. “Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Ductwork in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".

G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

1.3 FIRE RATINGS AND STANDARDS:

A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50 and Fuel Contributed 50.

B. All products and their packaging shall bear a label indicating above requirements are not exceeded.

C. Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.

D. Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.

E. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Johns Manville

B. Knauf

C. Owens-Corning.

D. Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

2.2 EXTERNAL INSULATION FOR SUPPLY AIR AND POSITIVE PRESSURE EXHAUST:

A. Knauf "Friendly Feel" faced, Duct Wrap, 0.75 PCF density, 2.2" thick or approved equivalent. Wrap shall be factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2" stapling flange at one edge. The installed R value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch. This applies to supply, return and outside air ductwork.

B. Round ductwork exposed within public spaces shall be double wall with a perforated inner liner. 1” thick insulation. Ductwork shall have a paintable surface. Rectangular ductwork exposed within public spaces shall be the same as 2.2A but with a canvas wrap.

2.3 EXTERNAL INSULATION FOR LOUVER PLENUMS AND MECHANICAL ROOM DUCTWORK:

A. Knauf "Insulation Board" or approved equivalent industrial insulation. Use 1½" rigid fiberglass industrial board with foil scrim kraft vapor barrier facing, 6.0 PCF density, K=0.22 Btu in/hr.ft²

°F @ 75°F. Use 1/2" thick, 1.6 PCF insulation board for round ducts. The installed R-value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch. Provide 6oz. canvas jacket with fire retardant lagging and provide a metal corner bead at all duct corners (on the exterior of the insulation) for protection. The corner bead shall be taped in place with foil scrim tape. This applies to all louver plenums as well as outside air, relief air, supply and return ductwork exposed within mechanical rooms.

2.4 INTERNAL INSULATION:

A. Where noted on the drawings, duct liner shall be 1" thick flexible elastomeric insulation (Armaflex AP Duct Liner). K=0.27 BTU in./hr. ft^2 °F @ 75°F.

2.5 DUCT SOUND ABSORBER / DUCTWRAP:

A. Where noted on the drawings, in addition to the duct insulation specified, install 1" thick Kinetics KBC-100RBQ (or Sound Seal BBC-1 B-10FS QFA-1) limp barrier material (1.3 lb./sq ft), reinforced with a fiber glass screen, loaded with barium sulphate, with a quilt faced fiber glass absorber on one side. Install per manufacturer's instructions. Minimum sound transmission loss per octave band shall be 125Hz-10dB/250Hz-16dB/500 Hz-22dB/1000Hz-30dB/2000Hz-39dB/4000Hz-43dB/STC-27. Provide steel banding to ensure restraint of duct wrap.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall photograph any installations prior to concealment.

B. Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to ductwork until tested, inspected and released for insulation.

C. Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

D. Duct insulation shall extend completely to all registers, grilles, and diffusers outlets, etc., to ensure no condensation drip or collection.

E. All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.

F. Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

G. Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

H. All insulation shall be installed with joints butted firmly together.

I. The Contractor shall insure that all duct insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold (air) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

1.1 SUMMARY

A. This section includes the following insulation for HVAC piping systems:
   1. Hot Water Piping
   2. AC Drain Condensate piping
   3. Chilled water piping
   4. Condenser water piping
   5. Mastics and adhesives
   6. Jacketing for insulated piping
   7. Refrigerant piping insulation

1.2 SCOPE

A. Work under this section shall include all labor, equipment, accessories, materials, and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

B. Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.

C. Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.

D. All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.

E. Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.

F. “Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or

equipment is not "concealed" as defined above. Piping in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".

G. The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

H. Schedule insulation application after pressure testing of systems has been approved by the engineer and where required, after installing and testing of heat tracing. Insulation application may begin on segments that have approved test results.

I. Product insulation against dirt, water and chemical and mechanical damage. Do not install damaged insulation; remove from project site.

J. Delivery insulation, covering, cements, adhesives and coatings to the site in factory-fabricated containers with the manufacturer's stamp, or label, affixed showing fire hazard ratings of the products.

K. Store insulation in original wrappings and protect from weather and construction traffic.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS – PIPING INSULATION

2.2 FIRE RATINGS AND STANDARDS:

A. Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding:
1. Flame Spread 25,
2. Smoke Developed 50
3. Fuel Contributed 50.

B. All products and their packaging shall bear a label indicating above requirements are not exceeded.

C. Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

D. Accessories such as adhesives, mastics, cements, tapes and cloth for fittings shall have the same component rating as listed above. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed requirements. Treatment of jackets or facings to impart flame and smoke-safety shall be permanent. The use of water-soluble treatments is prohibited.

E. Where Benjamin-Foster adhesives are specified equal products manufactured by 3M Company, or the manufacturer of the insulation are acceptable upon approval by the Engineer. Armstrong 520 adhesive shall be used for Armstrong insulation.

F. In lieu of the insulation wrap specified for fittings, valves, mechanical couplings and flanges, unitary type insulation products similar to J-M Unifit shall be acceptable.

G. In lieu of longitudinal lap seam specified, self-sealing lapped jacket shall be acceptable with requirement for aluminum bands on concealed piping in addition to stapling of lap seam.

2.3 Exposed, Interior (Interior Finished Rooms, Storage Rooms, etc.) Jackets:

A. Provide field-applied external pipe jacketing for all indoor exposed piping systems that are insulated. Jackets shall be continuously applied to both fittings and piping in all indoor exposed locations.

B. Pipe jacketing shall be one piece PVC pipe cover furnished in standard lengths, color coded per Section 230553, UV resistant, with self-sealing lap and adhesive strip. Thickness shall be 0.02". PVC shall be less than 25/50 fire smoke rated per ASTM E85.

C. Pipe fitting jacketing shall be two piece, color coded per section 230553, UV resistant, with self-sealing lap and adhesive strip. Thickness shall be 0.02". PVC shall be less than 25/50 fire smoke rated per ASTM E85.

2.4 PIPE INSULATION MATERIAL:

A. ACCEPTABLE MANUFACTURERS:
1. Armstrong World Industries
2. Certainteed Crimpwrap
3. Fibrex Insulations Inc.; Coreplus 1200
4. Knauf Insulation; 1000 Pipe Insulation
5. Manson Insulation Inc.; Alley-K
6. Owens Corning; Fiberglas Pipe Insulation
7. Johns Manville; Micro-Lok

B. Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

C. Hot water piping: Preformed fiberglass conforming to ASHRAE 90.1-2013, ASTM C547, Class I or II, and ASTM C585 with "K" factor of 0.27 Btu-in./h-sf-°F maximum at 75°F mean temperature. See schedule for thickness.

D. Chilled Water AC condensate drain and make-up water piping and chilled water pump housing: cellular glass or polyisocyanurate insulation, ASTM C 534 Type II with "K" factor of 0.27 Btu-in./h-sf-°F maximum at 75°F mean temperature. See schedule for thickness

E. Provide factory-applied ASJ/SSL type, ASTM C921, or ASTM C1136, Type I jacket with vapor barrier for cold piping (below ambient), or Type II for hot piping (above ambient). Type I may be used for both at Contractor's option. Factory-applied flap adhesive (SSL) or conventional staple and tape seal at Contractor's option.

F. Refrigerant Pipe Insulation: Armaflex-2 as manufactured by Armstrong. For piping surface temperatures from -40F to 180F, K-factor = 0.27.

G. Insulation Thickness Schedule (per 2018 NC Energy Code):

FLUID	Pipes 1.5” and smaller	Pipes 2” and larger
Condenser Water	1 ½”	1 ½”
Hot Water	1 ½”	2”
Chilled Water	1 ½”	1 ½”
Cooling coil condensate drain piping, make-up water and other drain piping.	1”	1 ½”
Refrigerant piping	1 ½”	1 ½”

2.5 ADHESIVES

A. Provide materials compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated Condensate and Equipment Drain: mineral-fiber, preformed pipe insulation, Type I.

B. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

C. ASJ Flashing Sealants
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Color: White

PART 3 - EXECUTION

3.1 GENERAL

A. Field Inspections shall be completed by Contractor-engaged agency. The Contractor shall photograph any installations prior to concealment. This includes risers in chases and at rooftop equipment.

B. Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, until tested, inspected and released for insulation.

C. Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.

D. All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.

E. Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.

F. Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!

G. All insulation shall be installed with joints butted firmly together.

H. The Contractor shall ensure that all piping insulation is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (water, refrigerant, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

I. Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. This applies to hot water lines only as cold water lines require continuous insulation and vapor barrier.

J. Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to insure no condensation drip or collection.

K. Valves, flanges and unions shall only be insulated when installed on cold fluid piping whose surface temperature will be at or below the dew point temperature of the ambient air.

L. Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool and seal with approved sealant.

M. Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:

PIPE SIZE	SHIELD GAUGE	SHIELD LENGTH
2” and less	20	12”
2 ½”- 4”	18	12”
5”- 10”	16	18”

N. Insulated pipes 2” in diameter and larger shall be additionally supported with wood inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond extend beyond the hanger and shall be at least 6” in length.

O. Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves, and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning is the process of ensuring that the HVAC System is installed and performs interactively according to the basis of design criteria and meets the building's operational performance expectations as defined in the sequences of operations. The process also provides adequate documentation of installation, start-up, and functional testing and ensures that the Owner’s maintenance personnel are adequately trained. It provides for discovery of system operational performance deficiencies prior to substantial completion while the responsible contractors can provide a timely response. It establishes testing and communication protocols in an effort to advance the HVAC System from installation to complete dynamic operation and optimization.

B. The commissioning process involves all the parties involved in the design and construction process as well as the Owner and the Commissioning Agent (CxA). Primary elements of Commissioning during the construction, acceptance, and warranty phases of the project include:

1. Verify applicable equipment and systems are installed in accordance with manufacturers’ instructions and contract documents and receive adequate operational start-up checkout by installing contractors.
2. Demonstrate functional operational performance of equipment and systems in the commissioning program.
3. Verify O&M documentation submitted is complete.
4. Verify Owner’s maintenance personnel are adequately trained in accordance with specified training plan requirements.
5. Furnish labor and material to accomplish HVAC system commissioning and systems testing as specified herein and other related sections.

1.2 RELATED SECTIONS

A. Section 01 7913 - Demonstration and Training

B. Section 01 7823 - Building System Manuals (O&M)

C. Section 019113 - General Commissioning Requirements

D. Section 019114 - Functional Testing Requirements

1.3 SUBMITTALS

A. Refer to Section 019113 for commissioning submittal requirements. Provide copies of commissioning submittal requirements to the Commissioning Agent, in addition to the copies required by the Owner and Design Professional.

1.4 COORDINATION

A. The installation schedule for the components, equipments & systems included in the commissioning program shall be such that the commissioning requirements can be met without impacting the construction schedule. Commissioning Functional Performance Testing is a requirement for Substantial Completion.

B. All maintenance points for components installed by the contractor (or sub-contractors) for building systems servicing shall be flagged utilizing construction marker ribbons if the maintenance point is located where multiple trades will be installing systems, unobstructed access from floor level shall be maintained. Refer to Section 019113 for additional information on maintenance/service point access.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Trade contractors shall provide all specialized tools, test equipment, and instruments required to execute startup, checkout, field calibration and functional performance testing of equipment under their contract.

B. Test equipment shall be of sufficient quality and accuracy (great accuracy than specified for component) to test and/or measure system performance according to specified tolerances. Test equipment is to have calibrated within the previous 12 months. Calibration shall be NIST traceable. Equipment shall be re-calibrated when dropped or damaged. Calibration tags shall be affixed or certificates be readily available.

C. Datalogging equipment or software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

PART 3 - EXECUTION

3.1 COMMISSIONING

A. General Requirements. For additional information regarding general commissioning requirements refer to Section 019113.

B. Installation contractors shall be responsible for executing and documenting equipment installation, start-up and check out for systems and equipment. Contractors shall also be responsible for executing and documenting Prefunctional performance tests. Both of these documents are required prior to the Commissioning Agent scheduling the functional performance test. Contractors shall also be responsible for providing training for the Owner's maintenance personnel in accordance with project requirements.

C. Prefunctional Checklist (PFC) for each type of equipment and system shall be provided to the installation contractors by the CxA via the web-based commissioning application for use by the contractors in documenting the installation and start-up of equipment in the commissioning program.

D. For equipment and system components requiring a manufacturer's representative for i Installation Verification and start-up, manufacturer documentation of these activities shall be attached to the checklists provided by the Commissioning Agent.

E. Prefunctional Performance Test procedures for each type of equipment and system shall be provided to the installation contractors by the Commissioning Agent for use by the contractor in documenting the performance of the Prefunctional performance test. Refer to Section 019114 for further information.

F. Completed Start-up checklists and performance test documentation for all pieces of equipment shall be submitted by contractors to the Commissioning Agent through the _____ prior to the scheduling of the final Functional Performance Test that is witnessed by the CxA.

3.2 TRAINING

A. Contractor responsible for the installation of the system shall coordinate the participation of other sub-contractors and manufacturer's representatives in the training program in accordance with requirements of 01 7823 - Building System Manuals (O&M).

3.3 OPERATIONS AND MAINTENANCE DATA

A. Contractor responsible for the installation of the system shall provide operations and maintenance manuals in accordance with requirements of other sections of the project specifications

3.4 GENERAL SYSTEM TESTING CRITERIA

A. Functional Performance Testing

1. Refer to Sections 019113 and 019114. Installation contractor shall be responsible for providing authorized manufacturer's representatives to demonstrate the operational capabilities of the equipments systems.

END OF SECTION 230800

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SECTION 230801 - COMMISSIONING OF BUILDING CONTROLS SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning is the process of ensuring that the Building Automation Systems (BAS) is installed and performs interactively according to the basis of design criteria and meets the building operational performance expectations as defined in the sequences of operations. The process also provides adequate documentation of installation, start-up, and functional testing and ensures that the Owner's maintenance personnel are adequately trained. It provides for discovery of system operational performance deficiencies prior to substantial completion while the responsible contractors can provide a timely response. It establishes testing and communication protocols in an effort to advance the BAS from installation to complete dynamic operation and optimization.

B. The commissioning process involves all the parties involved in the design and construction process as well as the Owner and the Commissioning Agent (CxA). Primary elements of Commissioning during the construction, acceptance, and warranty phases of the project include:

1. Verify applicable equipment and systems are installed in accordance with manufacturers' instructions and contract documents and receive adequate operational start-up checkout by installing contractors.
2. Demonstrate functional operational performance of equipment and systems in the commissioning program.
3. Verify O&M documentation submitted is complete. Provide required documentation and information to the Construction Manager to allow compilation of Building Systems Manuals in accordance with Section 01 7823.
4. Verify Owner's maintenance personnel are adequately trained in accordance with specified training plan requirements.
5. Verify systems are interacting and performing optimally in accordance with the system sequence of operations.
6. Furnish labor and material to accomplish building controls system commissioning and systems' testing as specified herein and other related sections.

C. Primary elements of BAS Commissioning during the construction, acceptance, and warranty phases of the project shall include:

1. BAS and equipment testing and start-up.
2. Verification of complete and thorough installation of BAS and equipment.
3. BAS performance verification.
4. Sensor checkout and calibration.
5. Control valve leak check.
6. Valve Stroke Setup and Check.
7. BAS Demonstration.

8. BAS Acceptance Period.
9. Trend logs and graphs.
10. Functional testing of BAS.
11. Documentation of tests, procedures, and installations.
12. Provision and coordination of BAS training.
13. Documentation of BAS Operation and Maintenance materials.
14. Warranty Phase BAS Opposite Season Trending and Testing.

1.2 RELATED SECTIONS

A. Section 017700 - Closeout Submittals

B. Section 019113 - General Commissioning Requirements

C. Section 019114 - Functional Testing Requirements

1.3 SUBMITTALS

A. Refer to Section 019113 for commissioning submittal requirements. Provide copies of commissioning submittal requirements to the Commissioning Agent, in addition to the copies required by the Owner and Design Professional.

B. Point-to-Point verification documentation shall be submitted to the CxA prior to scheduling the final functional performance test of the BAS system.

1.4 COORDINATION

A. The installation schedule for the components, equipments & systems included in the commissioning program shall be such that the commissioning requirements can be met without impacting the construction schedule. Commissioning Functional Performance Testing is a requirement for Substantial Completion.

B. All maintenance points for components installed by the contractor (or sub-contractors) for building systems servicing shall be flagged utilizing construction marker ribbons if the maintenance point is located where multiple trades will be installing systems, unobstructed access from floor level shall be maintained. Refer to Section 019113 for additional information on maintenance/service point access.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Trade contractors shall provide all specialized tools, test equipment, and instruments required to execute startup, checkout, field calibration and functional performance testing of equipment under their contract.

B. Test equipment shall be of sufficient quality and accuracy (great accuracy than specified for component) to test and/or measure system performance according to specified tolerances. Test equipment is to have calibrated within the previous 12 months. Calibration shall be NIST traceable. Equipment shall be re-calibrated when dropped or damaged. Calibration tags shall be affixed or certificates be readily available.

C. Datalogging equipment or software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

D. BAS contractor shall provide a portable operator's terminal or hand held device to facilitate the checking of sensor calibration. This device shall support all functions and allow querying and editing of all parameters required for proper calibration and start up. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the thermostat or the box.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCEDURES AND REQUIREMENTS

A. The Contractor is responsible for field calibration of all sensors and devices.

B. Through the commissioning process, the Contractor shall, to the satisfaction of the CxA:

1. Verify the installation, operation and functional performance of BAS systems hardware and software for compliance with design intent and the Contract Documents.
2. Document the data generated by tests and inspections. This documentation shall primarily be done in the CCF form and the Prefunctional performance test.
3. Verify accuracy and logical organization of Operation and Maintenance Manuals, as-built control sequences, and as-built program logic and setpoints.

C. A complete static and dynamic commissioning test program shall be implemented for all hardware and software points, all BAS panels and for all devices by the Contractor.

1. Static tests: Commissioning tests shall consist of a full range of static tests carried out to verify that all hardware points, software, panels, transducers, all devices and other components, function in accordance with the Specifications.
2. Dynamic tests: System performance shall be checked under dynamic conditions that simulate varying load and operating modes, including pre-conditioning, start-up, normal operating, emergency and fail-safe modes, shut-down interlocks and lock-outs defined in the Control Sequences.

D. The Contractor shall provide all commissioning test equipment required.

E. The CxA shall be given written notice at least seven (7) days in advance of the dates of all tests. Detail the locations and parts of system(s) being tested, the test procedures proposed and the anticipated results. The CxA shall witness testing to the level necessary to ensure testing protocols are acceptable and being followed.

F. Acceptance by the CxA of test procedures outlined in this Section shall not relieve the Contractor of responsibility for the complete system meeting the requirements of these Specifications after installation.

G. Final functional performance tests shall be performed for the BAS system as a whole and witnessed by the CxA.

1. Upon complete installation of the BAS system, the Contractor shall start up the system and perform all necessary testing and run diagnostics to ensure proper operation.
2. Pertinent sections of the Installation and Start-Up Contractor Certification Form (CCF) and a documented Prefunctional l performance test for the system shall be completed by the contractor prior to scheduling of the acceptance test.
3. A functional performance test, witnessed by the CxA, or designated representative, shall be performed for each system that includes integrated automation.

H. All testing, including the final functional performance test, shall be completed prior to substantial completion. If any check or test cannot be accomplished for seasonal reasons, lack of occupancy, or for other reasons, this fact shall be noted along with an indication of when the test shall be rescheduled.

3.2 STATIC COMMISSIONING OF THE INPUT AND OUTPUT HARDWARE

A. The Contractor shall complete a point-to-point check of the BAS system and provide documentation of same. The point-to-point checks and field sensor/device calibration shall be completed during the Contractor's own testing and verification. The documentation of field calibration of sensors and devices shall be recorded in the Installation and Start-Up Contractor Certification Form (CCF) specific system/equipment/component. Factory calibration of sensors shall not be accepted in lieu of field calibration. The completed point-to-point documentation shall then be submitted to the CxA for review and approval. The CxA shall repeat a random sample (20% minimum) of the point-to-point checks during the commissioning process to corroborate accuracy of the documentation. The Contractor shall be present on site with test equipment to repeat a random sample of the point-to-point checks and field calibrations. The procedures shall include the following:

1. Binary Input (BI) :
   a. BI status shall be verified at the Front End, local BAS control panel and equipment location for ON status and OFF status.
   b. All binary alarm inputs shall be proven using actual conditions where possible or be jumpered for testing with approval by the CxA at the field device to test for correct notification at the equipment location, local BAS control panel and front end.
2. Binary Output (BO)
   a. Status shall be verified at the equipment location. Verification at the Front End shall be completed for ON status, OFF status, software DISABLE indicator and OVERRIDDEN indicator.
3. Analog Input (AI)
   a. All temperature sensors shall be verified by conducting an equivalence test using a digital hand-held meter with equal or better accuracy.

b. Selected temperature sensors chosen by the CxA shall be verified by spraying with a "cold-spray" or other means to ensure response and to test the low temperature alarm condition.
c. All pressure sensing devices and analog output feedback shall be verified using a device with equal or better accuracy to ensure correct calibration. Calibration must be per Manufacturers' recommendations and to the CxA's satisfaction.
d. All humidity sensing devices must be verified using a psychrometer with equal or better accuracy to ensure correct calibration. Calibration shall be per Manufacturer's recommendations and to the CxA's satisfaction.
e. All CTs shall be set to accurately reflect motor status.
f. All other sensing devices shall be verified using an appropriate device with equal accuracy or better to ensure correct calibration. Calibration shall be per Manufacturer's recommendations and to the CxA's satisfaction.
g. Adjust span on feedback points so the analog input matches the end device output.

4. Analog Output (AO)
   a. AO's shall be tested by sending a command from the front end to incrementally stroke the field device from full CLOSED to full OPEN and measuring the signal at the field device. The increments of the test shall be no larger than 10% of output span.
   b. The AO feedback requirement shall also be tested by failing the field device and verifying that the alarm registers.
   c. Each output shall be exercised over the full output capability of the panel.
   d. Field device hysteresis shall be measured at a minimum of three output levels for each direction of travel. Output increments shall not exceed 2% of span for this test.

3.3 STATIC COMMISSIONING OF THE BAS SYSTEM SOFTWARE

A. The CxA shall review the final versions of all _____ system software to ensure that the software complies with the Control Sequences in every respect. The Contractor shall provide assistance and technical manuals as required.

B. The Contractor and the CxA shall commission the Front End graphics and reports.

3.4 STATIC COMMISSIONING OF THE BAS SYSTEM PANEL NETWORK AND DEVICES

A. Each BAS panel shall be checked for compliance with standalone and fail-safe requirements, proper grounding and other features. All features listed in Section 23 0900 shall be checked and verified by the Contractor in the presence of the CxA. Panels that do not pass the standalone tests shall be replaced at no cost to the Owner. In this context, "standalone" means that the panel, with the network cable disconnected, shall accurately maintain reference time, continue trending data, maintain communications with any panels connected to it and control the equipment connected to the panel.

3.5 DYNAMIC COMMISSIONING OF THE WORK AS A WHOLE

A. Functional Performance Testing

1. Refer to Sections 019113 and 019114. Installation contractor shall be responsible for providing qualified manufacturer's representatives to demonstrate the operational capabilities of the integrated automation systems.

B. Seven(7) Day Acceptance Test

1. The Seven (7) Day Acceptance Test shall be scheduled after successful completion of the functional performance test. This test shall occur after substantial completion to limit the contractor activities while the test is being performed.
2. With all points enabled and automatically controlled, all systems and associated programs shall operate for seven (7) consecutive days on history/trend logs to verify all types of conditions that occurred in the period.
3. All history/trend logs shall be set up by the Contractor and shall be submitted to the CxA for review and approval.
4. During the Acceptance Test period, the CxA may generate various failure scenarios to ensure the repeatable and acceptable recovery scenarios are achieved. This will focus primarily on the production areas of the facility.
5. The Contractor shall provide a minimum of seven day's worth of trend data to verify that the following functions:
   a. Systems operate in accordance with sequence of operations without manual intervention
   b. Reset schedules for setpoints are met
   c. Control loop stability without hunting
   d. Acceptable failure and recovery scenarios so as to maintain pressure cascades
   e. Contractor shall provide trend data at intervals and duration specified by the CxA at the start of the acceptance test period to determine that the above Control Sequences functions perform to his satisfaction.
6. This condition of the commissioning process is met when all alarms and system values are appropriate for the defined Control Sequences The Acceptance Test is considered a "PASS" if no unexpected outcomes are generated during the period. If unexpected outcomes do occur the test shall be considered a "FAIL". Depending on the criticality of the unexpected outcome, the contractor may be allowed to continue testing after modifications are made to complete the test period or may be required to start the acceptance test over.

3.6 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING:

A. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season functional performance testing. BAS contractor shall participate in this testing and remedy any deficiencies identified.

3.7 TRAINING

A. Contractor responsible for the installation of the system shall coordinate the participation of other sub-contractors and manufacturer's representatives in the training program in accordance with requirements of 01 79 00.

3.8 OPERATIONS AND MAINTENANCE DATA

A. Contractor responsible for the installation of the system shall provide operations and maintenance manuals in accordance with requirements of other sections of the project specifications

END OF SECTION 230801

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SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. METERS AND GAGES FOR HVAC PIPING
3. FACILITY MONITORING SYSTEM
4. VARIABLE FREQUENCY MOTOR CONTROL
5. HYDRONIC PUMPS
6. AIR HANDLING UNITS
7. VAV BOXES
8. EXHAUST FANS

1.2 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls. All labor, materials, tools, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned shall be included for the complete, fully functional and commissioned temperature controls system.

B. The contractor shall provide all items, articles, materials, devices, operations, or methods listed, mentioned, or scheduled on the drawings including all labor, materials, equipment, and incidentals necessary and required for their completion to provide a complete and operating temperature control system. This will include connecting to any mechanical equipment furnished with a control interface device and contacting the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished.

C. These apparatuses shall consist of, but not limited to, all necessary thermostats, sensing devices, valves, damper motors, actuators, and with the necessary accessories for the complete control of all equipment hereinafter specified.

D. Control sequences on plans. Provide all control equipment required to perform sequences described. Coordinate all dampers with the sheet metal contractor and equipment provider. It is

the responsibility of the control contractor to ensure all required dampers in the sequence of operations are provided.

E. Include all power wiring and cabling for the operation of the controls system. Refer to Electrical Division Specifications for additional requirements.

F. APPROVED MANUFACTURER'S: Instruments shall be provided by the Temperature Control Contractor. Refer to FACILITY MONITORING SYSTEM

G. The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.

H. Include monitoring of the flood sensor for the domestic water backflow preventers to send an alarm upon failure to the BAS.

1.3 ABBREVIATIONS:

A. TCC – Temperature Control Contractor

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. PC: Personal computer.

E. PID: Proportional plus integral plus derivative.

1.4 COST BREAKDOWNS

A. The contractor shall list the following cost breakdowns, material, and labor, on the official project schedule of values:
1. Controls shop drawings
2. Controls graphics
3. Controls materials and labor
4. Controls startup, commissioning, testing, documentation (2.5% of controls contract value)
5. Controls training and Owner acceptance (2.5% of controls contract value)

PART 2 - PRODUCTS

2.1 SENSOR RESOLUTION:

A. All temperature sensors shall have a minimum resolution of 1/10th of 1 degree F. (0.1-degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. Outside air, water and duct sensors shall be tested and accurate to within 1.0 degrees F.

2.2 WATER SENSORS:

A. Temperature sensors for water lines are to be the well type. Wells are to be threaded brass (same manufacturer as the temperature sensor) with the sensor coated with a heat transfer compound. Strap on sensors will not be acceptable.

2.3 OUTDOOR AIR SENSOR/ WEATHER STATION HOUSING:

A. Provide Kele Model A21 Outdoor Aspirated Humidity/Temperature housing. NEMA 3R enclosure is painted white to reduce the effect of radiation, and the enclosure has a lockable latch for security. Sensor Accuracy: +/-1 degrees F.

2.4 DISCHARGE AIR SENSORS:

A. Discharge air sensors shall be rigid insertion type.

2.5 FREEZE/LOW-LIMIT THERMOSTAT:

A. Provide a freeze/low-limit thermostat in each Air Handling Unit, Outside Air Unit, etc with a water coil for freeze protection. These devices shall be the manual reset type. This device shall be wired by using a normally closed contact in series with the motor starting circuit and a normally open set of contacts as an input to the unitary controller. The element shall be constructed of copper and be a minimum of one foot in length for every square foot of coil area.. The device shall sense the lowest temperature by any one-foot section of its element.

2.6 COMBINATION TEMPERATURE/HUMIDITY SENSORS:

A. All temperature sensors shall have a minimum resolution of 1/10th of 1 degree F. (0.1-degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. The humidity sensing device shall be 100% solid state, linear and temperature compensated with a 0-100% RH range. The response time shall be a minimum of 30 seconds for a 60% change. They shall have a minimum of 2% accuracy minimum accuracy of +/-2% RH minimum rangeability 5 to95% RH non-condensing and maximum hysteresis +/_1.5% RH. – Do not submit products that do not meet this range. The output of the device must utilize a 0-10 VDC or 4-20mA signal as required. The device must use a power

supply of 24 VAC or VDC. Duct mounted sensors shall have at least 4" insertion probe with a 16-gauge steel enclosure. NIST traceable certification shall be provided to the Engineer as part of the shop drawings. For wall mounted sensors the enclosure shall be polystyrene plastic mounted next to and at the same height as the temperature sensor in that area. Both shall have the same appearance.

2.7 LOW PRESSURE TRANSDUCERS:

A. These devises shall be 100% solid state, linear and temperature compensated. Accuracy shall be no less than plus or minus 1% of its full range. Linearity, repeatability, and hysteresis shall be no less that plus or minus 0.1%. All pressure sensors shall utilize output averaging/output clipping to adjust and stabilize any fluctuations in the output. The output of the device shall utilize a 0 - 10 VDC signal. The device shall use a power supply of 24 VAC or VDC. The enclosure 16-gauge steel. For sensing internal static pressure of air handling ducts utilize sensors with a rage of 0 to 5 inches water column. For sensing building static pressures (building compared to atmospheric) utilize a sensor with a range of -0.25 to +0.25 inches water column.

2.8 RELAYS:

A. Relays for starting and stopping fractional horsepower motors shall be rated as follows:
1. 1/4 horsepower motors or less use 15 ampere rated relays,
2. 1/3 horsepower motors use 20 ampere rated relays,
3. 1/2 horsepower motors use 30 ampere rated relays,
4. Relays used for pilot duty service shall be rated at a minimum of 10 amperes.
5. Provide auxiliary pilot duty relays on motor starters as required for control function.
6. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

2.9 SMOKE SHUTDOWN:

A. All OA units, Heat Pump Units, etc with fans of greater than 2,000 CFM are required to have smoke shutdown safeties as required by the Building Code. These smoke detectors shall have a set of auxiliary contracts wired to a dedicated input of the Unitary to provide status of the smoke detector. All units must be provided with a current sensor to provide fan status for each air handler. For projects with Outside Air (OA) units, any system fire alarm activation shall shutdown all OA units.

2.10 CURRENT SENSING DEVICES:

A. Veris Industries model Hx08 Series and H701 or equal. All current sensors shall be capable of alarming to the BAS for belt losses, pump coupling shear or other mechanical failure on loads.

2.11 DIFFERENTIAL PRESSURE TRANSMITTERS:

A. Provide Rosemount (ITT Bell & Gossett ST-102R) or equal field mounted differential pressure sensor transmitters as indicated on the plans. Range shall be 0-25 psig. Accuracy shall be .025% full span.

2.12 CARBON DIOXIDE SENSORS:

A. This sensor shall be electronic non-dispersive infrared (NDIR) type, diffusion sampling with LED or LCD display.
1. Measurement Range 0-2000/5000 ppm (programmable)
2. Accuracy ±30 ppm ±2% of measured value*
3. Repeatability ±20 ppm ±1% of measured value
4. Response Time <60 seconds for 90% step change
5. Input Power 20 to 30VDC/24VAC; 100mA max.
6. Analog Output 4-20mA, (clipped & capped)/0-5VDC/0-10VDC (selectable)
7. Operating Temperature Range 0° to 50°C (32° to 122°F)
8. 5-year calibration interval (recommended)
9. Low ambient sensitivity

2.13 AIRFLOW MEASURING STATION:

A. Ebtron (or equal) Model P+ GTC116, airflow measurement: Accuracy: ±2% of reading, Calibrated range: 0 to 5,000 fpm, NIST traceable calibration; Temperature measurement Accuracy: ±0.15 deg F, Calibrated range: 20 to 160 deg F, NIST traceable calibration. Coordinate cable length with manufacturer. Two isolated analog output signals (field selectable/scalable 0-5/0-10 VDC or 4-20mA.

2.14 VALVES, DAMPERS AND ACTUATORS

A. Unless otherwise specified, valves shall be furnished and sized by the contractor. The valves are to provide the required capacity and the close off rating shall be more than the system pressures encountered (minimum 40 psi differential). Proportioning-type valve bodies shall be packed type with throttling type inner valve (quick close plug shall not be acceptable). Proportional type valves to be rated at 125 psi static pressure. Modulating control valves shall be selected within a 3-5 psig pressure drop range. Two position control valves (open/close) shall be line size.

B. Dampers for various units requiring field mounting shall be tight closing, "ultra low leakage", opposed blade with side and edge seals. They shall be sized and furnished under this section. Installation of dampers shall be by the sheet metal contractor, coordinated by this contractor. Frames shall be no less than 16 gauge galvanized steel and furnished with mounting holes for duct mounting. Damper blades shall be no less than 14 gauge galvanized steel with maximum blade width of 8 inches. Blades shall be secured to 1/2 inch zinc plated axles and hardware with nylon bearings. Provide thrust bearings at the end of each blade. All dampers shall have end switches to positively prove damper position. No Exceptions!

C. All damper and valve actuators shall be fail safe spring return type with sufficient force to operate the dampers or valves under all normal operating conditions. They shall return to the normally open position upon a loss of power. Exceptions to the spring return applications are (1) face and bypass actuators. Actuators for terminal units, etc shall fail in the last position.

D. "ALL" Actuators shall be of the same manufacturer and have internal feedback circuitry to provide a positive action to ensure proper positioning of the damper or valve through the entire sequence. Actuators shall have an adjustable starting point to accurately set the range of travel to the output of the controller. All actuators shall also utilize the same input signal (6-9 VDC, 0-010V, 2-10 VDC, 4-20 MA) in order to maintain some consistency in the control application. Analog actuation is 6-9 VDC, 0-010V, 2-10 VDC or 4-20 MA, floating point control with 2 digital outputs is NOT approved as analog actuation.

E. Modulating control valves shall be from the same manufacturer. Actuators used with the valves may be from the vendor of choice provided they are approved for use by the valve manufacturer. The valve actuators shall be capable of opening and closing the valve against the rated shutoff head of the pump(s) serving the loop.

F. Heat pumps shall have 2-position ball valves. Belimo or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. A mandatory pre-installation meeting shall occur prior to the contractor beginning any work on site. This meeting shall be attended minimally the prime contractor, mechanical contractor superintendent, contractor superintendent, Engineer, Owner, and Architect. The purpose of the meeting is to have the controls installer communicate their understanding of the system design and how the system is intended operate to the Engineer and get the Engineer’s input and agreement. The agreement between the contractor and the mechanical engineer is to be thoroughly documented by the contractor for later reference.

B. The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable). The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.

3.2 SPACE SENSORS AND THERMOSTATS:

A. Refer to the drawings for proper type and location.

B. Heat Pumps, VRF and VAV Diffuser are shown to be provided with factory thermostats. Refer to plan for equipment and locations to be installed.

C. All thermostat and sensors shall be provided with temperature indication, unless otherwise noted.

D. Programmed set-point shall be locally adjustable limited to 2 degrees above set-point and 2 degrees below set-point for supervised areas.

E. Unsupervised areas shall have non-adjustable set-point.

F. Generally, thermostats/sensors shall be installed 5'-0" above the finished floor.

G. Where thermostats/sensors are to be mounted next to a light switch, install at the same height as the light switch.

H. If there is a question consult engineer prior to rough-in.

3.3 OUTDOOR AIR SENSOR:

A. The outdoor air sensor will be installed on the north wall in the shade as not to be affected by sunlight, building ventilation or weather. If not installed to provide “accurate” temperature it must be relocated (at the temperature control contractors expense) until such a location is found. Installation in outside air ductwork or louvers is not acceptable. This location must be indicated on the control drawings. There will be no exceptions to this unless approved by the consulting engineer and owner. The OAT sensor shall be wired directly to the heating system controller. If not installed to provide "accurate" temperature readings, it shall be relocated until a suitable location is found.

3.4 DISCHARGE AIR SENSORS:

A. In all applications, care shall be taken to ensure that the sensors are securely mounted as not to allow any vibration and installed in such a manner as to indicate the truest possible temperature.

3.5 FREEZE/LOW-LIMIT THERMOSTAT:

A. It shall be installed serpentine across the air entering the coil. In some cases, it may require being installed after the coil. Each application should be closely evaluated before installation.

3.6 OUTSIDE AIR UNIT:

A. All Air handling Units etc. shall be provided with current sensors on each of the supply and return fans to provide fan status for each air handler fan.

3.7 SMOKE SHUTDOWN:

A. Coordinate with the Fire Alarm Contractor to ensure a complete, code compliant installation.

3.8 VALVES, DAMPERS AND ACTUATORS

A. Actuators may be factory installed. If not, factory installed, they shall be installed as per instructions by the terminal equipment manufacturer.

B. Locations mounted above ceiling shall be marked on ceiling grid.

C. Install damper motors on the outside of the duct in warm areas where possible, not in air stream or locations exposed to outdoor conditions.

3.9 WIRE MANAGEMENT, ELECTRICAL POWER, ETC.

A. All work shall comply with the 2017 SCO Electrical Guidelines & Policies Section 260205 division of work between the Division 23 & Division 26 contractors.

B. Refer to CABLING section of this specification for additional requirements.

C. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.

D. All wiring and cabling in mechanical and electrical rooms shall be in conduit. No wiring or conduit can be exposed to view in any other area. Wiring above concealed ceiling shall route in bridle rings. Route wiring directly to cable tray from control points above the ceiling. Rough-in for control devices shall be in compliance with the requirements of the ELECTRICAL SPECIFICATIONS.

E. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for VAV terminals, heat pumps, etc.

F. The contractor shall perform all temperature control interlock wiring. This shall include control valves, dampers, thermostats, indoor/outdoor HVAC systems, etc. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.

G. All wiring shall be continuous runs. Any junctions must be made in metal enclosure.

H. Grounding terminals shall be color coded green and yellow and shall be compatible with the other specialty terminals specified above and shall mount on the same DIN rail system. Units shall be arranged so that the wiring connected to them is grounded to the enclosure via the mounting rail. These terminals shall be provided for grounding cable shields at the points where the cables enter a control panel and terminate on the control panel terminal strip. Terminals shall be Entrelec M 4/5.3A. PI or equivalent by Weidmuller, Phoenix, or Allen Bradley.

I. Only an electrical contractor licensed by the State with a licensed Master Electrician and a licensed on-site electrician can install the electrical wiring.

3.10 CABLING

A. Refer to WIRE MANAGEMENT section of this specification for additional requirements.

B. ALL CONTROL WIRING SHALL BE INSTALLED IN A WIRE MANAGEMENT SYSTEM TO INCLUDE CABLE TRAYS OR BRIDLE RINGS. NO EXCEPTIONS! COORDINATE WITH ELECTRICAL CONTRACTOR TO INSURE A COMPLETE WIRE MANGEMENT SYSTEM.

C. Acceptable cable manufacturers are Belden, West Penn, or Alpha.

D. Cabling shall be plenum rated and installed above ceiling and within walls not exposed to view.

E. A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance. Cabling shall be installed square with building lines and contained within a wire management system.

F. All sizing of cabling shall be according to manufacturer's recommendations but shall be a minimum of 18 AWG.

G. Furnish a floor plan of the building indicating communication cable labeling and routing as well as addresses and branch wiring from the unitary devices. All cabling shall be labeled on both ends. The type, size and label of all cabling shall be indicated on submittal floor plan drawings.

H. Wall space temperature sensor cabling (from the sensor to the unitary controller) shall have a minimum of four (4) conductors.

I. All cabling shall be stranded. "NO" solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.

J. All cable connections shall be continuous run (including shield). Any junctions must be made in a metal enclosure, connections must be soldered, taped and the metal enclosure must be mechanically attached to the nearest ground. No wire nuts or crimped connections will be accepted. Note location of junction boxes on the as built floor plans. All cabling networking unitary controllers, and other networked equipment, shall be in soldered.

K. All shields must be terminated as per manufacturer's recommendation. Shield termination requirements by the manufacturer must be provided with submittals.

L. Wireless controllers are not approved unless specifically mentioned in the sequence of operations or noted on plans.

3.11 COMMISSIONING & VERIFICATION, FUNCTION PERFORMANCE TESTING & CHECKLISTS:

A. 100% compliance with the requirements of this section is a condition of the Owner's acceptance and start of the warranty period.

B. The contractor shall be responsible for completion of (1) their hardware checkout sheets and test reports, (2) Point-by-point confirmations of ALL points – this includes visual inspection of installed components, and (3) sequence of operation confirmation.

C. This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals. Each subcontractor shall be responsible for completion of their own System Verification Checklists/Manufacturer's Checklists. Sample checklists shall be submitted to the Engineer and Testing Agent for approval.

D. Air and water balancing shall be completed (and discrepancies resolved) before the contractor's final system check and before the acceptance test to be conducted in the presence of the Engineer.

E. This project will be commissioned, and the contractor shall be responsible for completing the functional performance testing of the control system sequences and graphics with the Commissioning Agent.

3.12 WARRANTY

A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final acceptance and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.

B. The contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours. The contractor shall respond to the Owner's request for Emergency service (defined as life-threatening or creating the potential to cause property damage) during the warranty period within 4 hours.

C. The contractor shall provide technical phone support to the owner during the warranty period for warranty related issues and for two years after the warranty period. If the technical support location of the contractor is outside of the toll-free calling area for the customer, the contractor shall have a toll-free number or accept collect calls for the purpose of providing technical support.

D. During the warranty period, standard parts for the DDC system shall arrive at the facility within 48 hours of placing an order. Non-standard parts (requiring re-manufacturing or ordering from another supplier) shall be shipped within 96 hours.

END OF SECTION 230900

SECTION 230910 - BAS SENSORS AND DEVICES

PART 1 - GENERAL

1.1 APPLICABLE SECTIONS

A. 23 09 01 Building Automation Systems

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide BAS Components as indicated in the Contract Documents, Sequence of Operation, control diagrams, points lists, Specifications, or as needed to perform the intended operations consistent with the design intent of the BAS and design/performance intent of the MEP Equipment.

B. Provide with metal enclosure for all plenum applications. Any sensor mounted in plenum that has a plastic enclosure will be rated for plenum installation or installed in a plenum-rated enclosure.

C. All sensors shall be vibration and corrosion resistant.

D. Accuracy statements are written for the specific sensor. Installation shall not degrade accuracy more than double what accuracy statement for sensor requires.

E. Enclosures:
1. Provide suitable enclosure for BAS Component for ambient conditions encountered by application.
2. NEMA Type 1 or 2 for indoor and protected applications.
3. NEMA Type 3R, 4 or 4X for outdoor and unprotected applications.

2.2 Temperature Sensors, Standard Accuracy

A. Acceptable Manufacturers:
1. ACI (Basis of Design)
2. BAPI
3. Distech
4. Honeywell
5. JCI

B. General Requirements:
1. Sensor shall be thermistor or RTD inherently compatible with BMS.
2. Accuracy: ±0.5 deg F over 32 to 158 deg F range.
3. Operating Temperature Range: -40 to 300 deg F.

C. Outside Air Temperature (OAT) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance, with PVC sun and windscreen as required.

D. Duct-Mounted Single-Point Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe of length between one-third and two-thirds of the duct width in duct-mounted metal housing with conduit entrance.

E. Duct-Mounted Averaging Element Temperature Sensor: Multi-point sensor, contained in a flexible copper or woven continuous metallic sheath, with length sized for duct.
1. Provide a minimum of 1 foot of sensing element for every three square feet of duct/coil area. Multiple averaging elements may be required.
2. Averaging elements shall be used where ducts are prone to stratification, and downstream of heating/cooling coils.
3. Where multiple sensors are provided, sensors may be wired in a series-series, parallel-parallel pattern (requires four or nine sensors) in lieu of multiple inputs.
4. Plenum rated sheaths are not acceptable.

F. Wall-Mounted Flat-Plate Temperature Sensor: Stainless steel, flat plate sensor that fits in a standard 2-inch by 4-inch junction box with tamperproof screws. Provide with insulated back.

G. Thermowell-Mounted Immersion Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe, with three-part moisture protection system, that has minimum length of 20% of the pipe width. Provide machined, single-piece brass or stainless steel thermowell compatible with sensor housing.

H. Strap-On Piping Temperature Sensor: Sensor with metal clamps to fasten to piping. Strap-on sensors are only acceptable where specifically called for in Contract Documents. Thermowell and insertion sensor shall be installed where strap-on temperature sensor not specifically called for.

I. Cooler/Freezer Temperature Sensor: Use bullet probe style sensor.

2.3 Temperature Sensors, Matched Pair

A. Where two temperature sensors will be used together to calculate a BTU measurement, provide a matched pair.

B. General Requirements
1. All requirements for Standard Accuracy Temperature Sensors are applicable, except where more stringent below.
2. Sensor shall be thermistor or RTD with matched transmitter, bath calibrated, 4-20mA output proportional to temperature range and compatible with BAS and 24 Vac/dc power supply.
3. Differential Accuracy: ±0.15 deg F at 70 deg F.
4. Measurement Range: 32 to 200 deg F.
5. Range of sensor output shall be appropriate for the application the sensor is installed in. Range of the output shall be set at the factory and shown on the provided documentation.

2.4 Humidity Sensors, Standard Accuracy

A. Manufacturers
1. ACI (Basis of Design)
2. BAPI
3. Distech
4. Honeywell
5. JCI

B. General Requirements:
1. Laser-trimmed thermoset polymer-based capacitive-type sensor, 4-20mA or 0-10Vdc output proportional to relative humidity range of 0% to 100% and 24 Vac/dc power supply.
2. Accuracy: ±2 percent over 10 to 90 percent range.
3. Measurement Range: 0-100%.
4. Operating Temperature Range: -40 to 140 deg F.

C. Outside Air Relative Humidity (OAH) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance, with PVC sun and windscreen as required.

D. Duct-Mounted Relative Humidity Sensor: Sensor in duct-mounted plenum-rated housing with conduit entrance.

E. Wall-Mounted Relative Humidity Sensor: Sensor in white plastic enclosure with insulated back.

2.5 Combination Relative Humidity and Temperature Sensors

A. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, provide combination relative humidity and temperature sensors. The individual sensors must each meet the specifications details herein.

B. Where required in the drawings, combination relative and humidity sensors shall have the ability to output additional parameters, including dew point, enthalpy, and wet bulb temperature.

2.6 Wall Modules and Room Sensors, Standard Accuracy

A. General
1. Wall modules and room sensors cover devices which mount on a wall and provide an interface between the MEP Equipment and the occupant.

B. Manufacturers: Provide a wall module consistent with the manufacturer providing the overall controls.

C. General Requirements:
1. Wall modules which measure including but not limited to temperature, relative humidity, and/or carbon dioxide must each meet the specifications details herein.

2. Provide with plastic enclosure with display, temperature indication, occupancy override button, occupancy status indicator, and setpoint adjustment.
   a. Temperature indication will be absolute (in degrees Fahrenheit).

2.7 Dry (Air) Pressure Switch

A. Manufacturers
1. ACI
2. Cleveland Controls
3. Dwyer

B. General Requirements
1. Diaphragm pressure switch with SPDT contacts.
2. Sensor shall be uni-directional.
3. Manual or automatic reset, in accordance with Contract Documents.
4. Setpoint adjustment knob.
5. Accuracy: ±2 percent of full scale output.
6. Measurement Range: 0 to 12 in wg.
7. Operating Temperature Range: -4 to 185 deg F.

C. "Paddle-style" air flow switches are not allowed. Use dry pressure switch in lieu of paddle.

2.8 Dry (Air) Pressure Sensor, Standard Accuracy

A. Manufacturers
1. ACI
2. Honeywell
3. Setra
4. Veris (Basis of Design)

B. General Requirements
1. Diaphragm pressure transducer and amplifier type sensor, 4-20mA or 0-10Vdc output proportional to pressure range and compatible with BMS system and 24 Vac/dc power supply.
2. Sensor shall be uni- or bi-directional for application as stated below.
3. Sensor shall have local display.
4. Accuracy: ±1 percent of full-scale output/selected range.
5. Measurement Range: See applications below.
6. Operating Temperature Range: -4 to 140 deg F.
7. Burst pressure: 5 psid.

C. Duct-Mounted Static Pressure Sensors:
1. Uni-directional.
2. Measurement Range: 0 to 5 in wg. for low and medium pressure applications and higher as required for high pressure applications.

D. Room Pressure Sensors:
1. Bi-directional.

2. Measurement Range: -0.2 to 0.2 in wg.
3. Provide with surge damper (Amphenol SD-01 or equivalent) and room static pressure pickup with fine stainless steel mesh filter.

E. Building Pressure Sensors:
1. Bi-directional.
2. Measurement Range: -0.2 to 0.2 in wg.
3. Provide outside air reference kit, (Dwyer A-306 or equivalent), with tubing, mounting bracket and required hardware.
4. Provide with surge damper (Amphenol SD-01 or equivalent) and room static pressure pickup with fine stainless steel mesh filter.

F. Air Filter/Coil Differential Pressure Sensors:
1. Uni-directional.
2. Measurement Range: 0 to 2 in wg and higher as required.
3. Provide with static pressure probe(s).

2.9 Wet (Water) Pressure Switch

A. Manufacturers
1. Ashcroft
2. Dwyer
3. JCI

B. General Requirements
1. Diaphragm pressure switch with SPDT contacts.
2. Sensor shall have stainless steel wetted components in a weatherproof wiring housing.
3. Sensor shall be uni-directional.
4. Manual or automatic reset, in accordance with drawings.
5. Setpoint adjustment knob.
6. Accuracy: ±2 percent of full scale output.
7. Measurement Range: 0 to two times the setpoint or anticipated pressure.
8. Operating Temperature Range: -20 to 150 deg F.

C. “Paddle-style” water flow switches are not allowed. Use wet pressure switch in lieu of paddle.

2.10 Wet (Water) Pressure Sensor

A. Manufacturers
1. Ashcroft
2. Dwyer
3. Senva
4. Setra
5. Veris

B. General Requirements
1. Diaphragm pressure transducer and amplifier type sensor, 4-20mA or 0-10Vdc output proportional to pressure range and 24 Vac/dc power supply.

2. Sensor shall have stainless steel wetted components in a weatherproof wiring housing.
3. Sensor shall be uni-directional, unless bi-directional required for reversing flow.
4. Sensor shall have local display.
5. Accuracy: ±0.25 percent of full-scale output/selected range.
6. Measurement Range: See applications below.
7. Operating Temperature Range: See applications below.
8. Proof Pressure: two times rated input pressure, or greater.
9. Burst Pressure: five times rated input pressure, or greater.

C. Water "Gauge" Pressure Sensors:
1. Measurement Range: 0 to two times the setpoint or anticipated pressure.
2. Operating Temperature Range: 0 to 175 deg F.

D. Water Differential Pressure Sensors:
1. Measurement Range: 0 to two times the setpoint or anticipated pressure.
2. Operating Temperature Range: 0 to 175 deg F.

E. Provide with four or five valve manifold. Sensor to be connected to manifold at factory.

2.11 Current Switches/Transducers

A. Manufacturers
1. ACI
2. Setra
3. Veris

B. General Requirements
1. Sensor shall be rated for their associated motor load and voltage, have input and output isolation, and have LED indication of status.
2. Sensor shall be selected based on application, including but not limited to standard 60 hertz motors, variable speed drive, or ECM.
3. Accuracy: ±2 percent of full-scale output.
4. Measurement Range: 0 to two times the anticipated current.
5. Operating Temperature Range: 5 to 140 deg F.

C. Current Switch (CS)
1. Self-powered current switch with N.O. contacts.
2. Provide with adjustable trip point where indicated in Contract Documents, or as required for proper operation for application.

D. Current Transducer (CT)
1. Sensor with 4-20mA or 0-10Vdc output proportional to current draw and 24Vac/dc power supply.

2.12 Carbon Dioxide Sensors

A. Manufacturers
1. Honeywell

2. Vaisala
3. Veris

B. General Requirements
1. Non-dispersion infrared (NDIR) type sensor, 4-20mA or 0-10Vdc output proportional to carbon dioxide (CO2) range and 24 Vac/dc power supply.
2. Sensor shall have local display.
3. Accuracy: ±2 percent of reading, or 30 ppm, whichever higher.
4. Measurement Range: 0 to 2000 ppm.
5. Operating Temperature Range: 32 to 122 deg F.
6. Standard Calibration: No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing an automatic unoccupied period calibration.

C. Wall-Mount Carbon Dioxide Sensors: Sensor with plastic enclosure that fits on a standard 2-inch by 4-inch junction box.

D. Duct-Mount Carbon Dioxide Sensors: Sensor with sampling tube, duct-mounted metal housing with conduit entrance.

E. Where CO2 is provided beside temperature and/or humidity sensors, it shall be provided separately and not combined into a single sensor.

2.13 Light Level Sensors

A. Manufacturers
1. BAPI
2. PLC Sensors

B. General Requirements:
1. Power Supply: 12-28VDC, 22mA max
2. Measurement Range: see applications below
3. Output Range: 4-20mA
4. Accuracy: 10 Lux (1 footcandle) ±10% of reading
5. Environmental Operating Range: -40 to 185°F, 0-100% relative humidity, non-condensing

C. Outdoor Light Level Sensor: Sensor installed in weatherproof enclosure (IP66, NEMA 4) with integral sunshield. Measurement Range: 0 to 875 footcandles.

D. Indoor Light Level Sensor: Sensor installed on ceiling/wall. Measurement Range: 0 to 100 footcandles.

2.14 Airflow Measurement Station (AFMS)

A. Manufacturers
1. Ebtron
2. Air Monitor Corporation
3. Paragon Controls

4. Tek-Air Systems

B. General Requirements
1. Thermal dispersion type flow sensor, composed of one or more sensor probes (multiple sensors per probe) and transmitter, 4-20mA or 0-10Vdc output proportional to flow range and 24 Vac/dc power supply.
2. Measurement will be made using the principle of thermal dispersion. Provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node. Thermal dispersion devices that indirectly heat a thermistor are not acceptable. Other measurement technologies are not acceptable.
3. Sensor probe tubes and mounting brackets shall be constructed of gold anodized, 6063 aluminum alloy, 304 stainless steel, or 316 stainless steel.
4. Internal wiring in probes shall be resilient to exposure of moisture and not effect sensor operation.
5. Sensor probe shall be comprised of multiple sensors, with calibration data stored in the cable connecting plug, such that switching transmitters will automatically read corresponding calibration and sensor data. Quantity of sensors per probe and quantity of probes shall vary based on duct/fan configuration to provide the required accuracy.
6. Accuracy: ±3 percent of reading over full scale, when installed in accordance with manufacturer guidelines. ±5 percent of reading over full scale for outdoor air intakes, when installed in accordance with manufacturer guidelines. Accuracy is for installed air flow monitoring sensor, not for individual sensors in each probe.
7. Measurement Range: 0 to 5,000 feet per minute (fpm).
8. Operating Temperature Range: Probes: -20 to 160 deg F. Transmitter: -20 to 120 deg F.
9. Sensing elements will be NIST traceable.
10. Transmitter:
    a. Heavy-duty construction with LED display with 4-20mA air flow and temperature output signals. Outputs may be field configured for additional signals.
    b. Capable of communicating with BAS on communication protocol as specified in 230901.
    c. Transmitter shall generate alarms for individual sensor errors and transmit over the BMS network.
    d. Transmitter will be provided with Bluetooth low-energy interface card, capable of transmitting information to Android or iOS devices.

C. Duct Air Flow Measuring Stations: Probes will be ordered specific to duct as installed in field.

D. Fan Inlet Air Flow Measuring Stations: The sensing element shall be specifically designed to measure air flow of a centrifugal fan at the inlet cone. Coordinate mounting style with fan selection and manufacturer recommendations. For double-inlet fans, provide one set of elements for each inlet.

2.15 Insertion Electromagnetic Water Flow Meters

A. Manufacturers
1. Onicon FT-3500 Series (with Display)
    a. Or approved equal

B. General
1. Provide with NIST traceable, wet calibrated flow-measuring element, integral transmitter, installation valves, depth gage, calibration certificate, and attached tag indicating calibration information.
2. Flow meter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown.
3. Contractor shall be responsible for selecting flow meter options submitted based on application. Flow meter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions, and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.
4. Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.
5. 316L stainless steel construction.
6. Remote mountable display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.
7. Provide with installation kit appropriate for application from the same manufacturer as the flow meter.
8. Power Supply: 24 VAC/DC, 6VA max.
9. Measurement Range: in gpm, for range appropriate for application. Do not convert fps to gpm in BAS.
10. Output Range: 0-10V, 4-20mA.
11. Accuracy, when installed in accordance with manufacturer guidelines:
    a. ±1 percent of reading from 2 to 20 fps.
    b. ±0.02 fps at <2 fps.
12. Environmental Operating Range: -20 to 150°F.
13. Transmitter Enclosure Rating: NEMA 4.
14. Maximum Pressure Rating: 400 psig or greater.
15. Maximum Temperature Rating: 250°F or greater.
16. Flow Range: 0.1 to 20 fps.

C. Application
1. All hydronic applications, except domestic cold water.

2.16 Inline Electromagnetic Water Flow Meters

A. Manufacturers
1. Onicon FT-3200 Series (F-3000 Series with Advanced Transmitter)
    a. Or approved equal.

B. General
1. Provide with NIST traceable, wet calibrated flow-measuring element, integral transmitter, calibration certificate, and attached tag indicating calibration information.
2. Provide with ANSI class 150 or 300 flanges, according to Division 23/26.
3. Contractor shall be responsible for selecting flow meter options submitted based on application. Flow meter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow

rate, ambient conditions, and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.

4. Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.
5. Flowmeter shall consist of epoxy painted carbon steel outer body, 304 stainless steel flow tube and integral liner to be selected based on operating temperature and fluid.
6. Remote mountable display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.
7. Power Supply: 24 VAC/DC, 12VA max.
8. Measurement Range: in gpm, for range appropriate for application. Do not convert fps to gpm in BAS.
9. Output Range: 0-10V, 4-20mA.
10. Accuracy, when installed in accordance with manufacturer guidelines:
    a. ±0.2 percent of reading from 1.6 to 33 fps.
    b. ±0.0033 fps at <1.6 fps.
11. Transmitter Environmental Operating Range: 4 to 140°F.
12. Transmitter Enclosure Rating: IP67 or NEMA 4X.
13. Maximum Pressure Rating: 580 psig or greater.
14. Maximum Temperature Rating: 266°F or greater.
15. Flow Range: 0.1 to 33 fps.

C. Application
1. All hydronic applications, including domestic cold water.

2.17 Inline Ultrasonic Water Flow Meters

A. Manufacturers
1. Onicon F-4600 Series (with Display)
    a. Or approved equal

B. General
1. Provide with NIST traceable, wet calibrated flow-measuring element, integral transmitter, calibration certificate, and attached tag indicating calibration information.
2. Provide with NPT connections or ANSI class 150 or 300 flanges, according to Division 23.
3. Contractor shall be responsible for selecting flow meter options submitted based on application. Flow meter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions, and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.
4. Ultrasonic flow sensing element shall utilize matched direct path, wetted ultrasonic transducers and 1000 OHM Platinum RTD.
5. Flowmeter shall consist of a drop forged corrosion resistant metal flow body with process connections, integral transducers, and transmitter. All wetted materials shall be ANSI/NSF 61 & 372 compliant.
6. Remote mountable display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.

7. Power Supply: 24 VAC/DC, 5VA max.
8. Measurement Range: in gpm, for range appropriate for application. Do not convert fps to gpm in BAS.
9. Output Range: 0-10V, 4-20mA.
10. Accuracy, when installed in accordance with manufacturer guidelines:
    a. ±1 percent of reading over 25:1 turndown.
    b. ±2 percent of reading over 100:1 turndown.
11. Environmental Operating Range: -13 to 131°F.
12. Transmitter Enclosure Rating: IP65.
13. Maximum Pressure Rating: 400 psig or greater.
14. Maximum Temperature Rating: 250°F or greater.

C. Application
1. All hydronic applications, including domestic cold water, up to 2-1/2” inches.

2.18 BTU (Energy) Meters

A. Manufacturers
1. Onicon System 20
2. Onicon System 1000

B. General
1. Water flow meter, dual temperature sensors, and transmitter, 4-20mA or 0-10Vdc output proportional to flow range and each temperature (3 analog outputs total), and 24 Vac/dc power supply.
2. Provide water flow meter in accordance with the specification herein.
3. Provide matched temperature sensors in accordance with the specification herein.
4. Transmitter
    a. Provide with local display and operator interface. Display shall visually indicate instantaneous flow rate, supply temperature, return temperature, thermal energy flow rate (MBH).
    b. Capable of communicating with BAS on communication protocol as specified in 230901.

2.19 Thermostats

A. Manufacturers
1. ACI
2. Honeywell
3. JCI
4. Schneider Electric

B. General
1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF", "FAN HIGH-MED-LOW-OFF", or as applicable.
2. Mount on standard junction box.
3. Thermostat portion must meet the specifications details herein as required for application.

C. Digital Stand-Alone Thermostat
1. Electronic, solid-state, microcomputer-based room thermostat.
2. Automatic switching from heating to cooling.
3. PID control to minimize overshoot and deviation from setpoint.
4. Set up for four separate temperatures/periods per day, with individual programming for each day of the week (4 programs per day, 7 days per week, 28 potential programs).
5. Instant override of setpoint for continuous or timed period from 1 hour to 31 days.
6. Short-cycle protection.
7. Selection features include degree F or degree C display, 12- or 24-hour clock, keypad disable, and fan on-auto-circulate.
8. Powered off unit 24Vac transformer, with solid-state memory in which programming is retained on power failure. Battery acceptable only for time and date upkeep during power failure.
9. Thermostat display features include the following: time of day, actual room temperature, programmed temperature, programmed time, duration of timed override, day of week, and system mode indications include "heating," “cooling,” "off," "fan auto," “fan circulate,” and "fan on."
10. Combination Thermostat, Humidistat, Carbon Dioxide, and/or Occupancy Sensor: Where there is a requirement for a thermostat with humidistat, carbon dioxide, and/or occupancy sensing functions at the same location, provide combination unit. The individual sensors must each meet the specifications details herein.
11. Provide remote sensing element (electronic sensor) as required for application.

D. Low-Voltage, On-Off Thermostats
1. 24Vac, bimetal-operated, mercury-free, heat anticipator, concealed set-point adjustment, space temperature indicator, 55 to 85 deg F setpoint range, and 2 deg F maximum differential.
2. Selector Switch: Integral, manual on-off-auto.

E. Line-Voltage, On-Off Thermostats
1. Line voltage listed for electrical rating, bimetal-operated, mercury-free, open contact or bellows-actuated, snap-switch or equivalent solid-state type, heat anticipator, concealed set-point adjustment, space temperature indicator, 55 to 85 deg F setpoint range, and 2 deg F maximum differential.
2. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
3. Selector Switch: Integral, manual on-off-auto.
4. Combination Thermostat and Fan Switches: Push-button or lever-operated fan switch.

F. Freezestat/Low-Limit Duct Thermostat (LTD)
1. Manual reset switch.
2. Snap-acting SPDT with gas/refrigerant filled copper capillary that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint. Sensing range 15 to 55 deg F.
3. Bulb Length: Sized for duct/coil with minimum 5 feet.
4. Quantity: Provide a minimum of 1 foot of sensing element for each square foot of duct/coil area. Multiple Low-Limit Thermostats may be required.

G. High-Limit Humidistat
   1. Snap acting SPDT, duct or room mount, automatic reset switch that trips if humidity sensed is equal to or above setpoint. Sensing range 15 to 95% relative humidity.

H. Strap-On Piping Aquastat Temperature Sensor
   1. Snap acting SPDT, pipe mount, automatic or manual reset switch (as indicated in Contract Documents) that trips if temperature sensed is equal to or above setpoint. Sensing range appropriate for application.

2.20 Relays

A. Manufacturers
   1. IDEC
   2. Functional Devices
   3. Veris

B. General Requirements
   1. Electrically rated for application, minimally SPDT with 10A (resistive) contacts.
   2. Provide with LED indicator light.
   3. Provide with hand-off-auto (HOA) unless otherwise specified. HOA not required if controller has internal HOA or output being controlled has HOA (i.e. VFD).
   4. Plenum rated where required.

C. BAS Panel-Mounted Relays: “ice-cube” / socket style with mounting base and replaceable relay. Relays in panel will be screw terminal terminations; relays with wiring whip from factory are not allowed for panel mounting.

D. Nipple-Mounted Relays: enclosed relay compatible with conduit knockout. Acceptable for field use. With or without factory-provided wiring whip.

E. Track-Mounted Relays: acceptable for use in terminal unit control panels. Screw terminal terminations. Track-mounted relays are not to be installed in field unless inside an equipment control panel (i.e., no track-mounted relays in electrical boxes).

F. Combination Motor Starter / Current Switch Relays: allowed only for single-phase equipment and must be mounted such that pilot light is exposed (i.e., combination motor starter / current switch relays which install inside of motor starter/VFDs are not allowed). The individual sensors must each meet the specifications details herein.

2.21 Additional Sensors and Devices

A. Shaft-Mounted Limit Switches:
   1. Horizontal Shafts:
      a. SPDT/DPDT mercury-free, gravity-actuated mechanical switch with adjustable shaft connection. Kele TS-470-P or TS1-740-P, coordinate with shaft diameter.
      b. Provide when actuator has no integral end-switch capability.

2. Non-Horizontal Shafts (shafts in vertical or another plane):
    a. SPDT/DPDT mechanical whisker switch, 1/2" NPT conduit connection, NEMA 4X enclosure. Kele KLNJ-A2.
    b. Two SPDT auxiliary switch, adjustable switching point, direct mount to actuator. Belimo S2A.
    c. Provide when actuator has no integral end-switch capability, and gravity will not otherwise actuate mechanical switch.

B. Condensate Secondary Drain Pan Float Switch:
1. Rectorseal AquaGuard 1200+.
2. Universal metal or plastic secondary drain pan mounting. Clamp on installation shall not damage drain pan. Mechanical float switch with pull-up test knob and protective cover. Normally closed contacts. Exposed floats on brackets or whisker switch with foam float is not acceptable.

C. Condensate P-Trap with Integral Float Switch
1. Rectorseal EZ Trap 205 (3" deep) or 210 (1" deep), coordinate with equipment requirements and clearances.
2. Schedule 40 PVC P-trap with slip-fit integral mechanical float switch. Normally closed contacts. Watertight caps for access to clean trap and drain pan.
3. Provide when there is no auxiliary drain pan under equipment and a float switch is required.
4. In-line or auxiliary/secondary drain connection-style float switches are not acceptable.

D. Water Leak Detection Alarm:
1. Five second detection of dirty and purified water, deionized water, distilled water and reverse osmosis (RO) water. Local led for alarm with two SPDT contacts. NEMA 4 (IP66) enclosure.
2. Single-Point with Attached and Remote Sensor
    a. BAPI LDT4-PS and -RS series.
    b. Adjustable-height single-point sensor.
    c. Provide single-point sensor when enclosure can be mounted without direct exposure to potential leak. Provide remote sensor with appropriate length cable to remote-mount enclosure.
3. Rope-Style Sensing
    a. BAPI LDT4-RR series.
    b. Rope-style sensor with detection over length of entire rope, plenum rated, with detection at 1/8" of water.
    c. Provide rope sensor of sufficient length to surround potential leak area perimeter, coordinate with Contract Documents.

E. Emergency Stop Buttons: ADA-compliant, red emergency pushbutton in yellow polycarbonate plastic enclosure with clear flip-up cover and stainless steel backplate. Button shall be reset by twisting or pulling out the button; a procedure that requires disassembly or a key is not acceptable. 120V or 24 V as needed. Provide label with indication of operation (ex. "Boiler E-Stop"). Safety Technology International (STI) Stopper Station series or equal.

F. Spring Wound Timer Switch: Commercial single gang wall SPST timer switch with brushed nickel finish. Provide time cycle for number of hours as stated in the Contract Documents and no hold function. Provide label with indication of operation (ex. "Main Gym HVAC"). Application

for occupancy override or other as stated in the Contract Documents. Intermatic FF series or equal.

G. Standard Swing Door Magnetic Contact: Division 26 takes precedence, coordinate with Electrical Contractor and Door Vendor. Magnetic switch, screw mount (adhesive mount now allowed), screw terminals (wire whip not allowed). Install with wires unexposed in wall, coordinate rough-in requirements with drywall contractor. Honeywell 7939WG or equal.

H. Overhead Door Magnetic Contact: Adjustable magnet with L-shape bracket, armored cable whip with conduit fitting, standard gap 2", epoxy sealed for protection against moisture and impact. Honeywell 958/959 or equal.

I. Airflow Differential Pressure Air Flow Sensing Element: ABS/Polycarbonate pitot tube with "high" and "low" ports, insertion-style, integral flange with gasket, and push-on nipple for ¼" tubing. Application: for terminal units and/or VAV boxes which do not have a manufacturer-provided flow ring, or one which requires replacement. Not for use in any other applications, including but not limited to outside, return, exhaust, or supply airflow. Provide with differential pressure sensor as specified herein. KMC SS-1000 series or equal, length based on inlet diameter.

2.22 Electronic Actuators

A. Manufacturers: All valve actuators shall be supplied from a single manufacturer. All damper actuators shall be supplied from a single manufacturer. Provide actuators manufactured by one of the following:
1. Belimo (Basis of Design)
2. Honeywell
3. Johnson Controls
4. Schneider Electric (TAC Dura-Drive)

B. General
1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Actuators shall operate related valve(s)/damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the valve/damper is subjected.
3. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the designed pump/fan shutoff pressure as a minimum requirement.
4. Select actuators to fail in desired position in the event of a power failure. See Contract Documents for power failure modes.
5. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
6. Type: Motor operated, with gears, electric and electronic.
7. Voltage: 24Vac unless otherwise specified. 120V actuators may be allowed if coordinated by BAS Contractor with Electrical Contractor to provide local disconnect and power. Circuit must be fed from the same power panel as the MEP Equipment or Control Panel and a spare circuit must be available.
8. Power: Contractor is responsible for sizing control transformers based on the VA of the actuator(s) selected.

9. Provide electronic overload protection throughout the entire operating range in both directions.
10. Coupling: V-bolt and V-shaped, toothed cradle. Bolt and set screw method of attachment is unacceptable.
11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
12. Two-Position Actuators: Single direction, spring return or non-spring return type.
13. Modulating Actuators:
    a. Capable of stopping at all points across full range and starting in either direction from any point in range.
    b. Control Input Signal:
        1) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input, the actuator remains in the last position.
        2) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 0-5Vdc, 0-10Vdc, 1-5Vdc, 2-10Vdc, and 4-20mA signals.
    c. Floating control actuators shall be allowed only for damper and valve control for room terminal units where there is not a room pressurization requirement. See General Requirements for definition of those spaces. Use of floating controls must be specifically requested by Contractor for specific spaces and reviewed by Owner. Submission of floating control actuators without specific comment by Contractor for spaces and the resulting review by Owner does not constitute approval for use.
    d. Pulse width modulation (PWM), or any other analog signal that is not specified above is not allowed.
14. Position Feedback: Where indicated, equip two-position actuators with auxiliary switches (SPDT) for remote monitoring of open and/or closed position. Point of open and/or closed position can be adjusted over the actuators range of operation (0-100%). Where indicated, equip modulating actuators with a position feedback through current and/or voltage signal for remote monitoring.
15. Fail-Safe: Where indicated, provide actuator to fail via a mechanical spring return mechanism, to drive controlled device to an end position (open or close) on loss of power. Electronic fail-safe is not allowed, unless specifically reviewed and accepted by Owner. Provide external, manual gear release on non-spring return actuators.
16. Temperature Rating:
    a. Standard Dampers and Valves: -22 to +122 deg F.
    b. Smoke Dampers: -22 to +250 deg F.
17. Provide actuator enclosure with a heater and thermostat where required by application.
18. Stroke Time:
    a. Normal: 120 seconds or less from fully closed to fully open, or fully open to fully closed.
    b. Fast-Acting: 12 seconds open, 5 seconds closed unless otherwise noted.

C. Damper Actuators
1. The total damper area operated by an actuator shall not exceed 80 percent of damper manufacturer's maximum area rating.
2. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison off a single control signal.

3. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
4. Use shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
5. Actuator will mount directly to damper with coupler as described above. No foot mount kits, jackshafts, or linkages shall be used.
6. Sizing: Size for running torque calculated as follows:
   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sqft. of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sqft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sqft. of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sqft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1,000 to 2,500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2,500 to 3,000 fpm: Increase running torque by 2.0.

D. Smoke and Combination Fire/Smoke Damper Actuators
1. Actuator shall come connected to damper as a rated assembly, sized per the damper manufacturer's requirements, and meet the specifications herein.
2. Actuators operating in smoke control systems shall comply with governing code and NFPA requirements.

E. Valve Actuators
1. Valve actuators will be direct coupled "rotary-style" unless otherwise specified. Where required, direct coupled "linear-style" actuators may be used.
2. Sizing
   a. Hydronic: Size for torque required to achieve valve close off at 150% of maximum pump differential pressure.
   b. Steam: Size for torque required to achieve valve close off at 150% of steam design pressure.

2.23 Control Valves

A. General
1. Applications for where to use each valve specified is provided in 3.12Control Valve Schedule.
2. Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
3. Control valves assemblies shall be provided and delivered from a single manufacturer as a complete assembly, with the actuator installed at the factory.
   a. Assembly will come tagged by factory with the valve assembly full model number, Cv (pressure-dependent), gpm (pressure-independent), size, and the application (i.e., AHU-1-CHWV).
   b. Tag shall provide no question as to what valve is intended to be installed on what MEP Equipment.
4. Control valves shall be two- or three-way as specified in Contract Documents.
5. Provide with extended neck as part of the valve body, or standoff/offset of the actuator, as required, to accommodate insulation thicknesses.
6. Refer to Division 23 for general information about valve construction and installation.

7. Provide control valves in accordance with 3.12Control Valve Schedule.
8. Sizing
    a. Independent of the control valve type, the valve shall be no smaller than two line sizes from piping. This is the piping as designed by the Owner Representative, and not the MEP Equipment runout size.
        1) For example, a 2 inch piping is used to supply MEP Equipment with a 1-1/2 inch connection to the coil. A 1-1/4 inch valve is acceptable based on two line sizes below the 2 inch piping. A 1 inch valve is unacceptable.

B. Hydronic Ball-Style Control Valves
1. Manufacturers
    a. Belimo (CCV series)
    b. Honeywell (VB series)
    c. Schneider Electric (VBB/VBS series)
2. Construction
    a. 2-Inch NPS and Smaller: 350 psi at 250 deg F brass/bronze body, stainless steel ball with matching blow-out proof stem, full port with stainless steel or composite characterizing insert, Teflon seats, dual EPDM O-ring seals, solder or threaded ends.
    b. 2 1/2-Inch NPS and Larger: 175 psi at 250 deg F iron body, stainless steel ball and matching blow-out proof stem, full port with stainless steel or composite characterizing insert, Teflon seats, dual EPDM O-ring seals, ANSI Class 125/150 flanged ends.
    c. ANSI class IV seat leakage for two-way, ANSI class IV seal leakage for three-way A-Port and class III for B-Port.
3. Flow Characteristics
    a. Two-way two-position valves shall be full port.
    b. Two-way modulating valves shall be characterized with equal percentage characteristics.
    c. Three-way valves shall have equal percentage characteristics on A-Port and linear characteristics for B-Port. Bypass applications shall have linear percentage characteristics.
4. Sizing
    a. Two Position: Line size or size using a 1 psig pressure differential.
    b. Two-Way Modulating: Size using 4 psig or equal to the load pressure drop, whichever is greater.
    c. Three-Way Modulating: Size using 4 psig or equal to the load pressure drop, whichever is smaller.
    d. Effective Cv: for any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect. Provide effective Cv on submittal.

C. Hydronic Butterfly-Style Control Valves
1. Manufacturers
    a. Belimo (HD Series)
    b. Honeywell (VFF Series)
2. Construction
    a. 2 to 12-Inch NPS: Class 125/150 cast-iron full-lugged body, stainless steel disc, EPDM seat and extended neck. Disc-to-stem connection shall utilize an internal spline.

b. 14-Inch NPS and Larger: Class 125/150 cast-iron full-lugged body, stainless steel disc, EPDM seat and extended neck. Disc-to-stem connection shall utilize a dual-pin method.
c. Leakage: 200 psid zero leakage for 2 to 12-inch NPS and 150 psid zero leakage for 14-inch NPS and larger.

3. Sizing
a. Two Position: Line size or size using a 1 psig pressure differential.
b. Two-Way Modulating: Size using 3 psig or equal to the load pressure drop, whichever is greater. Size for the design flow with the disc at 60-degree open position and the design velocity less than 12 FPS.
c. Effective Cv: for any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect.

D. Pressure-Independent Hydronic Ball-Style Control Valves
1. Manufacturers
a. Belimo (PIQCV up to 3/4"; ePIV for 1" and up)
b. Honeywell
c. Bell & Gossett Ultra Setter
2. General
a. Valve shall meet all the requirements set forth in the Hydronic Ball-Style Control Valve section, in addition to the requirements below.
b. Operating Differential Pressure Range: 5 to 50 psid or better.
c. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valves shall accurately control the flow from 0 to 100% full rated flow.
3. Construction
a. Mechanical pressure regulation style PIC valves shall have factory installed pressure/temperature test ports (Pete's Plugs) across the pressure regulator at the factory.
b. Pressure independent control valves 1" NPT or larger may use ultrasonic flow measurement. The ultrasonic flow meter will meet the specifications herein.
4. Flow Characteristics: see Hydronic Ball-Style Control Valves.
5. Sizing
a. Valve shall be sized for the larger of:
1) 110% of the GPM specified for the MEP Equipment, or
2) The GPM specified for the MEP Equipment, plus 1 additional GPM.
b. Valve shall be provided based on scheduled flow, but upsized where required to match the requirements above.

PART 3 - EXECUTION

3.1 General Installation

A. Install aspirating guards on wall-mounted devices in the following locations:
1. Building entrances.
2. Public areas.
3. Where indicated on construction documents.

B. Exposed wire nuts, including in plenum, will not be acceptable. All connections will be made inside a rated enclosure.

C. Install labels and nameplates to identify control components according 230901.

D. Install hydronic instrument wells, valves, and other accessories according to Division 23.

E. Install refrigerant instrument wells, valves, and other accessories according to Division 23.

F. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

G. Coordinate fire alarm relay connections to the fire alarm system with the fire alarm installer.

H. Where sensors have a display, mount such that display can be read from ground. When remote mount display is provided, mount at 48 inches above floor in mechanical rooms.

I. Install sensors in visible and accessible areas. Do not hide sensors on top of ductwork or insulate over sensors.

J. For sensors on rigid insulation for duct or piping, install sensor prior to insulation. Sensors installed after insulation will be required to cut and seal insulation around sensor.

K. Sensors requiring an external power source shall use DC power from switching DC power supply. Do not use alternating current for sensors unless specifically required by the manufacturer. Do not use on-board DC power for sensors unless specifically required by the manufacturer.

L. For sensors with a factory-whip, terminate whip inside electrical box with grommet for whip, no more than 24 inches from sensor. Exposed whip shall be plenum rated. Wire connections shall be made inside the electrical box.

3.2 Temperature/Humidity/Wall Module and Room Sensors Installation

A. Verify location of thermostats, humidistats, and other exposed control sensors with Contract Documents and room details before installation. Install devices 48 inches above the floor per ADA requirements. The location(s) to be selected by Owner. No sensor shall be mounted until the Owner and/or Owner Representatives give specific location instructions. Do not install sensor(s) on the inside of exterior building walls (including column fur outs) unless explicitly approved by Owner.

B. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

C. Install outdoor air temperature and humidity sensors on north-facing wall at designated location. If sensor cannot be placed on north wall, submit RFI for approved location and provide with PVC sun shield and windscreen.

D. Single-point temperature sensors may be used in ducts where there is no air stratification possibilities. Sensor shall be mounted sufficiently downstream to allow for sufficient mixing, five to ten duct diameters at a minimum.

E. Install mixing plenum sensors in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip.

F. Thermowells to be installed in piping. Contractor to "stub-up" any thermowell which is too long to install directly into piping. Install heat-conducting fluid in thermowell prior to installing sensor.

G. Install heat-conducting fluid where strap-on temperature sensors contact piping. Sand and clean piping prior to installation. Insulate around sensor.

H. Install cooler/freezer sensors in rubber clamp to isolate sensor from surrounding metal. Run conduit inside cooler/freezer for sensor away from door and storage racks. After sensor has been checked out, seal all penetrations with low expansion insulating foam. Coordinate installation with cooler/freezer vendor.

I. Install humidity sensor in areas where relatively humidity will not rise above 90% RH. If area will have high humidity consistently, relocate to different area and use dewpoint/ psychrometric calculations to calculate relatively humidity of the area required.

J. Wall Modules
1. Limit setpoint adjustment to ±3 deg F unless otherwise specified on the Drawings.
2. Display will be configured to match Owner's requirements, coordinate with Owner.

3.3 Pressure Sensor Installation

A. Supply (Positive) Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube/probe. Make pressure tap connections according to manufacturer's recommendations.

B. Return (Negative) Duct Static Pressure. Pipe low-pressure tap to duct using a pitot tube/probe. Make pressure tap connections according to manufacturer's recommendations.

C. Room Pressure: Pipe appropriate pressure sensor port (positive space: high pressure, negative space: low pressure) to room. Pipe opposite pressure point to reference outside of room. Connect to stainless steel mesh snubber mounted to white 2 in by 4 in plate at locations on drawings.

D. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through outside air reference kit. Mount kit per manufacturer's instructions. Pipe high-pressure port to stainless steel mesh snubber mounted to white 2 in by 4 in plate at locations on drawings.

E. Pressure transducers, except those controlling VAV boxes, shall be located in Control Panels, not on MEP Equipment or on ducts. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

F. Do not install tees for TAB purposes in air pressure tubing. Remove tees where found.

G. Install differential pressure sensor valve manifold at eye level. Provide hard copper tubing from water mains to valve manifold; soft copper not allowed. Provide isolation valves in tubing prior to valve manifold.

3.4 Current Switches/Transducer Installation

A. Wire may be “wrapped” around CS/CT to obtain better status indication.

B. CS/CTs requiring commissioning/startup will be done per manufacturer installation instructions.

3.5 Light Level Sensors

A. Outdoor Light Level Sensor: Install sensor facing north, away from reflective surfaces (i.e., white roof, metal, etc), in a non-shaded location with an unobstructed view of the horizon.

B. Indoor Light Level Sensor: Install sensor with no direct lighting in its field of view (indirect lighting only).

3.6 Air Flow Measurement Stations (AFMS) Installation

A. Install AFMS in locations indicated and required to perform the Sequences of Operation. Install AFMS in accordance with the manufacturer’s recommendations.

B. Do not install AFMS sensors and probes until all sanding and grinding activities are complete to protect them from accumulating dust and debris.

C. Prior to ordering, measure actual duct size as installed in field and provide to vendor.

D. Mount transmitter at eye level. Measure distance from probe to transmitter and order wire whip of sufficient length to reach. Install probe wire whip in conduit of sufficient size for connector to pass through.

3.7 Water Flow and BTU Meter Installation

A. Install water flow meters in locations indicated to perform the Sequences of Operation. Install water flow meter in accordance with the manufacturer’s recommendations.

B. Do not install AFMS sensors and probes until all sanding and grinding activities are complete to protect them from accumulating dust and debris.

C. Prior to ordering, measure actual pipe size and verify furnished material as installed in field and provide to vendor.

D. Mount transmitter at eye level. Measure distance from probe to transmitter and order wire whip of sufficient length to reach. Install probe wire whip in conduit of sufficient size for connector to pass through.

E. Provide installation kit (i.e., threadolet, nipple/standoff, pipe tee, isolation valve, etc) to Mechanical Contractor for installation. Kit will be specific to the application. Installation accessories which are not provided by the vendor will not be acceptable.

3.8 Thermostats

A. Install Freezestat/Low-Limit Duct Thermostat (LTD) in ducts and plenums in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip. Provide rows at 12 inch spacing; the element covers a maximum of 6 inches above and below sensing element. At the bottom of the duct or plenum, the row with the tail end of the sensing element shall be a maximum of 6 inches from the bottom.

3.9 Relays

A. Nipple-mount relays will be mounted at a location where pilot light is visible from floor.

3.10 Additional Sensors and Devices Installation

A. Shaft-Mounted Limit Switches: install outside of air stream to actuate at 90% or greater opening. Provide sufficient whip length for operation.

B. Condensate Secondary Drain Pan Float Switch: installed in an accessible but remote area, away from equipment service clearances.

3.11 Valves, Dampers, and Electronic Actuators Installation

A. Wire parallel actuators according to manufacturer's recommendations.

B. Dampers and Damper Actuators
1. Install automatic dampers according to Division 23.
2. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.
3. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately the 5° open position, manually close the damper, and then tighten linkage.
4. Provide necessary mounting hardware and linkages for actuator installation.
5. Install damper motors on outside of duct in climate controlled areas, including mechanical rooms. Provide sufficient standoff/offset of damper actuator from ductwork to allow for insulation behind actuator.
6. Where clearance cannot be maintained, locations exposed to outdoor temperatures, or actuator is inside ductwork, provide 12 inch by 12 inch access door per specifications for any actuator inside of ductwork.

C. Control Valves and Valve Actuators
1. PIC Valves
a. Where not provided from the factory, install pressure/temperature test ports (Pete's Plugs) for testing of pressure differential across the PIC valve.
b. For PIC valves with electronic flow metering, coordinate with mechanical contractor to ensure 5 pipe diameters of straight pipe entering valve.
2. Steam Valves
a. Mount actuators at a minimum 30 degree angle compared to vertical. Do not mount actuator directly above steam valve or piping.

3.12 Control Valve Schedule

SERVICE	TYPE	PIPE SIZE	VALVE TYPE	PRESSURE INDEPENDENT (YES/NO)	FAIL SAFE PER 2.22B.15 (YES/NO)
Hydronic Heating Coils, Terminal Units Only[1]	2-Way Modulating	3/4" and Smaller	Characterized Ball Valve	No	No
	3-Way Modulating[2]				
Hydronic Heating and Cooling Coils, Generic Application	2-Way Modulating	6" and Smaller	Characterized Ball Valve	Yes	Yes
	3-Way Modulating[2]	2" and Smaller		No	Yes
	3-Way Modulating[2]	2-1/2" and Larger	Consult Owner for Alternate Application		
Hydronic Heating and Cooling Plants, Generic Application	2-Way Modulating	6" and Smaller	Characterized Ball Valve	No	Yes[4]
	3-Way Modulating	2" and Smaller		No	Yes[4]
	3-Way Modulating	2-1/2" and Larger	Butterfly Valve	No	Yes[4]
Hydronic Isolation, Generic Application	2-Way, 2-Position	1" and Smaller	Full-Port Ball Valve	No	Yes[4]
	2-Way, 2-Position[3] (Modulating Actuator)	1-1/4" to 3"			
		4" and Larger	Butterfly Valve	No	Yes[4]

1. Terminal units include variable air volume boxes and fan powered variable air volume boxes. Provide valves in accordance with "Hydronic Heating Coils, Generic Application" if application in question is not a terminal unit.

2. Provide 3-way valves only where specifically specified or required. Where minimum flow bypass is provided for pumps, do not provide 3-way valves.
3. Provide with modulating actuator to allow for slower staging on/off of equipment.
4. Unless otherwise specified.

END OF SECTION 230910

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SECTION 230920 - VARIABLE FREQUENCY MOTOR CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor's attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. INSTRUMENTATION AND CONTROL FOR HVAC
3. FACILITY MONITORING SYSTEM
4. HYDRONIC PUMPS
5. DEDICATED OUTDOOR-AIR UNITS

1.2 SCOPE OF WORK

A. All VFD shall adhere to the latest manufacturers recommended installation, wiring and networking practices.

B. Include all power wiring and cabling for the operation of the VFD. Refer to Electrical Division Specifications for additional requirements.

C. The distributor shall have an established working relationship with the manufacturer of not less than five years and shall have prior approval from the Owner and Engineer and are the only allowed suppliers and/or installing contractors. The distributor shall have a local office within 100 miles of the project site and provide service and/or replacement parts within a 24-hour notification of a control failure.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFDs):

A. VFDs shall be as manufactured by ABB, Danfoss, or Yaskawa. These are the only acceptable manufacturers. All VFDs for the project shall be by the same manufacturer (no exceptions).

B. VFDs shall be consist of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.

C. The VFD shall be capable of operation form AC voltage in two rages 208–240 VAC ± 10%, or 380–480 VAC ± 10%. 50/60 HZ operation, ± 2 hertz.

D. The VFD enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated, suitable operating conditions: 0 – 400 C continuous. Drives that have thermal cut out circuits, or that cannot operate continuously at 400 C shall not be acceptable. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing.

E. The VFD shall produce an adjustable AC voltage/frequency output for step less motor speed control utilizing sine wave coded Pulse Width Modulation (PWM) The Drive shall provide automatic power factor correction and a .98 displacement power factor by incorporating a full wave diode bridge rectifier. The VFD shall have an overload rating of 110% of nominal rated current for 1 minute out of every 10 minutes of operation, which is an acceptable overload for centrifugal loads.

F. The VFD shall include a built-in first environment RFI/EMI filter and be CE and UL labeled. It shall also meet the CE requirement of EN61800-3 which provides an actual test procedure that shows that the VFD is immune from RFI/EMI interference and at the same time does not emit RFI/EMI noise that would interfere with other sensitive equipment near the VFD.

G. The VFD shall include as a minimum a 5% dual DC link and AC line reactor for a clean harmonic signature, which aides in complying with IEEE-519-1992 recommended levels. The VFD manufacturer and representative shall assist in ensuring that the VFD's applied meet IEEE-519-1992 by completing a computer aided Harmonic Analysis of the complete system. Refer to electrical drawings and coordinate with electrical contractor for all required information to complete analysis.

H. The VFD shall include as a standard a built-in digital keypad/display panel. This panel shall provide "Hand" off "Auto" selection, and a manual speed adjustment via up and down arrows. All faults and warnings shall be provided in "Plain English" for operation without a manual. The drive shall have a complete manual stored in memory that can be accessed with a single keystroke. This display shall be password protected and allow all setup parameters to be adjusted only by authorized personnel.

I. The VFD shall include built in Startup, Diagnostic, and Maintenance assistants, which allow for step-by-step startup procedures, troubleshooting, and the ability to indicate when the VFD and the system it is applied to needs preventive maintenance performed.

J. The VFD shall include a real time clock with a day/date stamp for troubleshooting purposes. In addition, with the use of this clock the drive shall be capable of stand-alone operation and act as a unitary controller.

K. The VFD shall include (2) Analog inputs either 4–20 madc or 0-10 vdc, (6) programmable Digital Inputs, (2) Programmable analog Outputs, (3) Form C Relay output rated 2 amps continuous minimum, and (2) PID Process controllers.

L. The VFD keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.

M. BYPASS: All VFD's shall be provided with an integral Bypass circuit, as scheduled, which includes a pair of 115V electrically interlocked contactors for drive and bypass operation. The drive shall include a main input circuit breaker, drive input service/isolation switch, and motor overload protection adjustable for either Class 10, 20 or 30 operations. The bypass shall include a built-in status display which shows via colored LED's the system operational status including safeties and run permissive for ease of operation. The Bypass shall have its own interactive, programmable keypad. The Bypass shall provide single-phase protection for the motor while operating in bypass. Bypass that does not protect the motor from single-phase operation shall not be acceptable.

N. The drive and bypass system shall have embedded serial communication capabilities that allow direct connection to Siemens and BACnet automation systems as part of the drives software suite without the need for extra hardware cards or gateways. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC).

PART 3 - EXECUTION

3.1 GENERAL

A. The work includes all labor, materials, and related items to completely furnish and install, start up and test, and place into service the Variable Frequency Drives (VFDs) indicated and scheduled on the Drawings and described in the Specifications.

B. All VFDs shall be provided and installed in strict accordance with the manufacturer's recommendations.

C. Factory-authorized startup for each drive is mandatory. Provide a written record of the startup of each unit. Start up and programming by a factory-authorized technician. At startup, lockout any speed with the VFD that does not meet the vibration allowanced of the equipment manufacturers.

D. A parts and labor warranty of 3 years from startup and 2 years from the date of final acceptance shall be included. Warranty shall include travel time and expenses.

END OF SECTION 230920

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SECTION 232100 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

PART 1 - GENERAL

1.1 GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor shall include all excavating, filling, grading, and related items required to complete their work as shown on the drawings and specified herein or as required to complete, connect, and place all mechanical systems in satisfactory operation.

C. Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2’-0" to the side.

D. Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be concrete encased for a distance not less than 5 feet on either side of the point of crossover.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EARTHWORK CLASSIFICATION:

A. Without regard to the materials encountered, all excavation and materials excavated shall be unclassified. Materials to be excavated shall be unclassified, and shall include earth, rock, concrete, or any other obstructions encountered in excavation and/or trenching to install underground utility pipes or other equipment.

B. Include all costs for rock removal, including mass rock and trench rock in the bids. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating. The Contractor shall be responsible for the removal of all materials encountered as required for the installation of the work.

C. It shall be distinctly understood that references to rock, earth, topsoil or any other excavated or non-excavated material or other material on the construction plans, cross section, contract documents, technical specification, or provisions, whether in numbers, words, letters, lines or graphically shown, is solely for information for the Engineer and Owner. This information shall not be taken as an indication of the classification of the material to be excavated, bored, or

removed by any method, including drilling and blasting, or materials not removed. This information shall not be taken as to the quantity of either rock, earth, topsoil, or any other material involved, or the quality of the material such as hardness, wetness, workability, or suitability of the material either during excavation and construction or as a material to be reused during construction.

D. The Contractor shall draw their own conclusions as to the surface and sub-surface conditions to be encountered during construction of this project. The Engineer and Owner does not give any guarantee or warranty as to the accuracy of the data shown and no claim will be considered for additional compensation when the materials encountered are not in accord with the information shown.

E. Refer to Specification Division EARTHWORK located in the Site Work portions of the Specifications and Civil Drawings for additional information. Also refer to the GEOTECHNICAL report included in the Front End of the Specifications.

3.2 BENCHMARKS AND MONUMENTS:

A. Maintain carefully all benchmarks, monuments, and other reference points. If disturbed or destroyed, replace as directed.

3.3 EXCAVATION:

A. Excavate trenches of sufficient width for proper installation of the work. Excavate to 6" below the bottom of new pipes for installation of compacted grillage.

B. Sheet and brace trenches as necessary to protect workers and adjacent structures. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.

C. Rules and regulations governing the respective utilities shall be observed in executing all work under this Division. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineer.

D. Machine excavation shall not be allowed within ten (10) feet of existing electric lines, natural gas lines or other lines carrying combustible materials. Use only hand tools.

E. The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Engineer. Any damage to existing structures, exterior services, or rock intended for bearing, shall be corrected at the responsible Contractor's expense.

F. Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to ensure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell or flange and/or is supported with blocks or wedges will not be accepted.

G. Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper joining of pipe. Any dewatering from this Contractor's trenches which is required during construction, shall be included in this Contract.

H. In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, large trees to remain, etc. The Contractors shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be at the responsible Contractor’s expense.

I. Use surveyor's level to establish elevations and grades.

J. Machine excavation shall be held a sufficient distance from foundations and footings to ensure no damage to same. Contractors shall accept full responsibility and pay for repairs and/or replacement of structural members, footings, etc.

K. The Contractor shall accept the site as it is and remove all trash, rubbish, and material from the site prior to starting excavation work.

L. The Contractor shall provide and maintain barricades and temporary bridges around excavations as required for safety. Temporary bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.

M. Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.

N. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor’s expense.

3.4 BACKFILL, COMPACTION AND SURFACE REPAIR:

A. Backfilling for Mechanical Work shall include all trenches, manhole pits, storage tank pits, and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed, and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.

B. All trenches shall be backfilled with 6" of manufactured sand or #8 crushed stone after finished excavation. Install the new pipe on the compacted fill material. Install tracer wire on pipe. Apply any special coatings to the pipe. Also perform all required pressure tests and check the grade of the pipe to ensure that it is correct and free of swags, bows or bends. Once coatings and testing are complete, backfill the pipe bed to 12" above the top of the pipe with specified compacted fill material. Backfill the remainder of the trench with earth (rock and debris free) tamped at 6" intervals. Water settling of backfill is permitted only as an aid to mechanical compacting.

C. Backfill and compact beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean topsoil.

D. Backfill and compact beneath paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill or unstable soil.

E. Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.

F. Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.

G. Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.

H. If not specified or indicated elsewhere in the Contract Documents to be performed by Others, the Contractor shall lay new sod over their excavation work for existing disturbed grassy areas. Level, with adjacent surface, compact and water in accord with sound sodding practice.

I. Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated as follows.

J. At a minimum, fill in grass areas shall be compacted to 90% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.

K. At a minimum, fill in concrete or asphalt area shall be compacted to 98% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.

L. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

M. Grading Outside Building Lines:
1. All materials used for backfill around structures shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, large rocks, wood, and other extraneous material. All spaces excavated and not occupied by footings, foundations, walls, or other permanent work shall be refilled with earth up to the surface of the surrounding ground, unless otherwise specified, with sufficient allowance for settlement.
2. In making the fills and terraces around the structures, the fill shall be placed in layers not exceeding 8 inches in depth and shall be kept smooth as the work progresses. Each layer of the fill shall be compacted. Sections of the fill immediately adjacent to buildings or structures shall be thoroughly compacted by means of mechanical tamping or hand tamping as may be required by the conditions encountered. All fills shall be placed so as to load structure symmetrically.
3. As set out hereinbefore, rough grading shall be held below finished grade and then the topsoil which has been stockpiled shall be evenly spread over the surface. The grading shall be brought to the levels as specified. Final dressing shall be accomplished by hand work or machine work, or a combination of these methods as may be necessary to produce a uniform and smooth finish to all parts of the regrade. The surface shall be free from clods greater than one inch in diameter. Excavated rock (1" and smaller) may be placed in the fills, but is shall be thoroughly covered. Rock placed in fills shall not be closer than 24 inches from finished grade. Refer to Specification Division EARTHWORK.

N. Maintenance Settling: Where settling is measurable or observable at excavated areas during Project Warranty Period, remove surface (pavement, concrete or any other surface or finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work and eliminate evidence of restoration.

O. Disposal of Excess Non-organic Soil and Rock: Any excess excavated waste material shall become the property of the Contractor and shall be disposed of by the Contractor off site at no additional cost to the Owner.

P. Unless otherwise directed by the Owner during construction, excess topsoil, and subsoil suitable for fill shall be disposed of by the Contractor off site at no additional cost to the Owner.

3.5 MINIMUM DEPTHS OF BURY TO TOP OF PIPE:

A. In the absence of other indication, the following shall be the minimum depth of bury to top of pipe of exterior utility lines. Check drawings for variations.
1. All Other Lines Not Listed 36 inches below final grade.

B. All exterior lines shall have a minimum earth cover of forty-eight (48) inches to top of pipe, unless otherwise indicated.

END OF SECTION 232100

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SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.

C. The Contractor's attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS LISTS FOR HVAC.

D. The Contractor's attention is directed to Specification Section HVAC PIPING INSULATION.

E. The Contractor's attention is directed to Specification Section HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING.

1.2 SCOPE

A. Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified.

B. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.

C. The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.

D. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.

E. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

F. Dielectric couplings or through ways shall be provided at all connections of dissimilar materials.

G. Nipples shall be of the same material, composition, and weight classification as pipe with which installed.

H. Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief, or exhaust plenums.

I. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.

J. When connecting to an existing hydronic water system (chilled, hot, etc.), the Contractor shall include cost to drain the existing piping system and refill with water/closed loop chemicals to match existing fluid. If the building is occupied, and the drain down will affect services to these occupied areas, then the systems shall be drained and refilled over a weekend at a time acceptable to the Owner.

K. This work shall consist of furnishing all labor, material, equipment and services necessary for the installation of all equipment specified hereinafter.

L. Systems, piping and components principally relevant to this section include:
1. Hot water supply and return piping and fittings.
2. Chilled water supply and return piping fittings.
3. Condensate drain and makeup water supply piping and fittings.
4. Condenser water piping and fittings.
5. Other items where shown on the drawings or as specified.
6. Refrigerant liquid and hot gas piping and fittings

PART 2 - PRODUCTS

2.1 CHILLED WATER AND HOT WATER SUPPLY AND RETURN PIPING AND FITTINGS

A. Fittings 2" and smaller shall be ASTM B88 copper type L hard drawn copper tubing with 125 psi solder joint wrought copper fittings.

B. Fittings 2 ½" and larger shall be ASTM A53 Grade B welded steel, standard weight.

C. All steel fittings shall conform to ASA B16.4, B2.1 and ASTM A-126 Class A.

D. Welded fittings: With the exception of pipe welded end-to-end, all welding joints shall be made by the use of one-piece welding neck flanges, nozzles, elbows, tees, etc. All welding elbows shall be long radius elbow. Welding end fittings shall have the same pressure class as pipe of the same size and schedule. Tee fittings shall be one piece except that shaped nipples are permitted where branches are at least two pipe sizes less than the main.

E. Flanged fittings: Flanges and flanged fittings shall conform to ASA Standard B16.5 and ASTM-A181 for 150 lb. class.

F. THREADED FITTINGS 2" AND SMALLER SHALL BE MALLEABLE IRON CONFORMING TO ANSI B16.3 (150 PSIG WP) WELDED FITTINGS SHALL MATCH SCHEDULE OF PIPE, BLACK STEEL CONFORMING TO ASTM A120. WELD-OUTLETS MAY BE USED IN LIEU OF FITTINGS FOR BRANCH TAKE-OFFS FROM MAINS 2" OR

LARGER PROVIDED THAT THE BRANCH TAKE-OFFS AREA TWO OR MORE SIZES SMALLER THAN THE MAIN. NO “STUB-INS” WILL BE PERMITTED.

G. Threaded joints shall be made with Teflon sealing compound applied to the male threads only.

H. Piping which is sized 2" and smaller shall be socket welded.

I. Welding fittings: With the exception of pipe welded end-to-end, all welding joints shall be made by the use of one-piece welding neck flanges, nozzles, elbows, tees, etc. All welding elbows shall be long radius elbow. Welding end fittings shall have the same bursting pressure as pipe of the same size and schedule. Tee fittings shall be one piece except that shaped nipples are permitted where branches are at least two pipe sizes less than the main.

J. Flanged Fittings: Flanges and flanged fittings shall conform to ASA Standard B16.5 and ASTM-A181 for 150 lb. and 300 lb. class.

2.2 CONDENSATE DRAIN PIPING AND MAKE-UP WATER SUPPLY PIPING AND FITTINGS

A. Pipe material for above ground installation shall be type "L" hard drawn copper tubing with 125 psi solder joint wrought copper fittings.

B. Fittings for copper pipe shall be wrought copper, or cast brass.

C. Provide floor drains where shown on drawings.

2.3 REFRIGERANT PIPING AND FITTINGS

A. Piping: Soft ACR copper.

PART 3 - EXECUTION

3.1 GENERAL

A. For purposes of clearances and legibility, the contract documents are diagrammatic and, although size and location of piping are drawn to scale wherever possible, contractor shall make use of all data in all of the contract documents and shall verify this information at building site.

B. The contract documents indicate required size and approximate points of termination of pipes and suggest proper routes of piping to conform to structure, avoid obstructions and preserve clearances. However, it is not intended that the contract documents indicate all necessary offsets, and it shall be the work of this section to install piping in such a manner as to conform to structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or cost to the Owner. The contractor shall fully inform himself regarding any and all peculiarities and limitations of the spaces available for the installation of all work and materials furnished and installed under the contract. He shall exercise due and particular caution to determine that all parts of his work are made quickly and easily accessible. Although the locations of the equipment and piping may be shown on the contract documents in certain positions, the contractor shall be guided by the architectural details and conditions existing at the job, correlating this work with that of others. Provide all offsets as required to produce a neat, workmanlike arrangement.

C. The contractor shall study all drawings and specifications to determine any conflict with ordinances and statutes. Any errors or omissions shall be reported, and any changes shall be shown in drawings made by this section, and any additional work performed at no additional cost to the contract.

D. Submittal of bid shall indicate the contractor has examined the site and contract documents and has included all required considerations in his bid. No considerations shall be made for any error resulting from contractor's failure to visit job sites and to review contract documents and bid shall include costs for all required drawings and changes as outlined above, all at no additional cost to the contract.

E. All piping shall be installed to prevent unusual noise from the flow of water under normal conditions.

F. Springing, bending or forcing of pipe shall not be allowed. Use fittings for all offsets or changes in alignment of piping.

G. All changes in directions shall be made with approved fittings. Mitering, saddling or welding of smaller pipe and larger piping is prohibited.

H. Pipe openings shall be closed with caps or plugs during installation. Rags and tin cans are not considered suitable closures. Pipe openings in terrazzo floors shall have semi-permanent closures during construction.

I. Damage by leaks – This Division 23 contractor shall be responsible for damage to the grounds, walks, road, buildings, pipe systems, electrical systems and their equipment and contents, caused by leaks in the piping system being installed or having been installed herein. He shall repair at his expense all damage so caused. All repair work shall be performed as directed by the Construction Manager.

J. The use of chemicals or so-called "Stop-Leak" compounds shall not be permitted at any time.

K. Unions shall be provided at connection to all equipment.

L. Escutcheon plates shall be provided at all penetrations of walls, ceilings, floors, etc.

M. All items of equipment shall be provided with approved vacuum breakers to prevent backflow, as required by State Health Department and local authorities having jurisdiction. All waste connections shall be installed with approved airbreak fittings to comply with the above requirements. Vacuum breakers where shown on Drawings or required shall be angle pattern with built-in lift type check valves as manufactured by Bidoro Manufacturing Company or approved equal.

N. Bypass Piping: Except as otherwise indicated, fabricate and install bypass piping using same materials and in same plane as connected piping, but one pipe size smaller. Include valve in bypass piping. Install bypass piping around control valves, PRV stations and as shown on drawings.

O. Drain Valves: Install on each mechanical equipment item located to completely drain equipment for service or repair. Install at base of each riser, at base of each rise or drop in piping system, and elsewhere where indicated or required to completely drain hot or chilled or condenser water piping system.

3.2 PIPE JOINING METHODS

A. Steel Pipes Joints (2" and smaller):
1. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

B. Pipes Larger than 2"
1. Weld pipe joints (except for exterior water service pipe) in accordance with ANSI Code for Pressure Piping, B31.
2. Weld pipe joints of exterior water service pipe in accordance with AWWA C206.
3. Install flanges on all valves, apparatus and equipment. Weld pipe flanges to pipe ends in accordance with ASME B31.1.0 Code for Pressure Piping. Clean flange faces and install gaskets. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.
4. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

C. Joints for other piping materials are specified within the respective piping system sections.
1. Weld pipe joints in accordance with ANSI B31. Weld pipe joints in accordance with recognized industry practice and as follows:
   a. Weld pipe joints only when ambient temperature is above 0°F (-18°C) where possible.
   b. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
   c. Install welding rings for buttwelded joints.
   d. Use pipe clamps or tack-weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
   e. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures

which shall ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

f. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

g. At Installer's option, install forged branch-connection fittings wherever branch pipe of size smaller than main pipe is indicated; or install regular "T" fitting.

D. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

3.3 CHILLED WATER AND HOT WATER SUPPLY AND RETURN PIPING SYSTEM

A. The drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and coordination between trades without additional cost.

B. Pipework shall conform fully to the following requirements:

1. Provide proper provision for expansion and contraction in all portions of pipework, to prevent undue strains on piping or apparatus connected therewith. Provide double swings at coil connections riser transfers and other offsets whenever necessary to take up expansion. Arrange riser branches to take up motion of riser.
2. Approved bolts, gaskets, flanges (screwed or welded) shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions shall be provided as specified on piping 2-1/2" or less.
3. All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges so arranged that the equipment can be serviced or removed without dismantling the piping.
4. Provide dielectric unions or installing flanges for copper or brass to steel piping system joints.
5. If, after plant is in operation, any apparatus is stratified or air bound (by vacuum or pressure), they shall be repiped with new, approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, these contractors shall bear all expense of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

C. Miscellaneous drains, vents and reliefs are to be provided as follows:

1. Provide 3/4" hose and drain valves with cap near the heel of all water risers in an accessible location.
2. Miscellaneous drains, vents, reliefs, and over-flows from tanks, equipment, piping, relief valves, pumps, etc. shall be run to the nearest open sight drain or roof drain. Provide 3/4" drain valves with caps for complete drainage of piping, including the system side of all pumps.
3. Provide domestic water connections from valves outlets to any equipment requiring same, including expansion tanks.

D. Screwed piping shall conform to the following:

1. Pipe Nipples: Any piece of pipe 3" in length or less shall be considered a nipple. All nipples with unthreaded portion 1-1/2" and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples shall be provided.

2. Screw threads shall be cut clean and true: screw joints made tight without caulking. No caulking shall be permitted. A non-hardening lubricant shall be used. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings. All pipe shall be reamed out after cutting to remove all burrs.

E. Welding piping shall conform to the following:
1. All welded joints for steel pipe shall be of the open V-butt following approved welding procedures for metallic arc or oxyacetylene carbon steel welded pipe joints. Pipe shall be mill beveled or machine beveled by this trade. All scale and oxide must be removed with hammer, chisel or file, and the bevel left smooth and clean.
2. Weld metal shall be thoroughly fused with base metal at all sections of weld and penetration of weld shall include unbeveled portion and shall extend to inside walls of pipe.
3. Pitch water piping upward in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer. Branch connection to mains are to be made in such a manner to prevent air trapping and permit free passage of air. To meet job conditions mains shall be set up to maintain headroom, and clear other trades. Provide oversized float operated automatic air vent (with valve and strainer) at all high points in hot and chilled water piping, particularly at the highest points of return mains and risers. Avoid 90 degree lift set-ups in supply lines by using 45 degree ells. Where 90 degree lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents to an open sight drain if the vent is concealed, or to within two feet of the floor within machine rooms.

3.4 REFRIGERANT PIPING

A. Install refrigeration specialties in accordance with manufacturer's instructions. Route piping in orderly manner, parallel to building structure and maintain gradient. Install piping to conserve building space. Do not interfere with the service requirements of equipment. Group piping wherever practical at common elevations and locations. Slope piping one percent in the direction of oil return.

B. Provide non-conducting dielectric connections when joining dissimilar metals. Install piping to allow for expansion and contraction without stressing piping, joints or connected equipment.

C. Provide clearance for installation and access to valve and fittings.

D. Provide insulation on all piping. Provide aluminum jacket on all outdoor piping.

E. Fully charge complete system with refrigerant after testing.

F. Test refrigeration system in accordance with ANSI/ASME B31.5.

G. Pressure test system with dry nitrogen to 400 psig. Perform final tests at 27" vacuum and 200 psig using electronic leak detector. Test to no leakage.

H. Provide shield plates to protect piping rom damage. Label piping as "Warning – Risk of Fire – Flammable".

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications, apply to this Section.

1.2 SUMMARY

A. Section Includes: This section covers general requirements for valves and specialties that are used with piping systems as specified elsewhere in Division 23.

1.3 SUBMITTALS

A. Product Data: The following data shall be provided in the submittal:
   1. Strainers
   2. Hydronic Specialties
   3. Diaphragm/bladder expansion tanks
   4. In-line air purgers
   5. Air separators

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Refer to Division 23 Section "General Provisions for Mechanical" for general code, standard and regulatory requirements.
   2. Chemical and physical properties of materials, performance characteristics, and methods of construction shall be in accordance with applicable sections of the following references and standards of current editions in effect 90 days prior to receipt of bids:
      a. American Welding Society (AWS)
      b. Commercial Standards, National Bureau of Standards (CS)
      c. Compressed Gas Association (CGA)
      d. Copper Development Association (CDA)
      e. Federal Specifications (FS)
      f. Manufacturers Standardization Society (MSS)

PART 2 - PRODUCTS

2.1 AIR VENTS

A. Manual vent - Brass petcock, 1/4" size, with threaded flare fitting for drain tubing connection.

2.2 UNIONS

A. Malleable-iron, Class 150 for low pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

2.3 DIELECTRIC UNIONS

A. Provide dielectric unions with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

2.4 STRAINERS

A. Y-type Strainers: Provide strainers full line size of connecting piping, with ends matching piping system materials. Screens shall be Type 304 stainless steel, with 3/64" perforations at 233 per square inch.

B. Provide strainers with 125 psi working pressure rating for low pressure applications.

C. Threaded Ends, 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

D. Threaded Ends, 2 1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Flanged Ends, 2 1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

F. Butt Welded Ends, 2 1/2" and Larger for Low Pressure Application: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

G. Butt Welded Ends, 2 1/2" and Larger for High Pressure Application: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

H. Grooved Ends, 2 1/2" and Larger: Tee pattern, ductile iron or malleable iron body and access end cap, access coupling with EDPM gasket.

2.5 WATER FILTERS

A. Pall Trinity Micro Corporation, Ronningen-Petter, Consler, Filterit or Commercial Filters (Carborundum).

B. Carbon steel housing rated at 150 psig at 250F filter access with bolted and gasketed steel or cast iron head, threaded for 2" and smaller, flanged for 2-1/2" and larger.

C. Construct filter cartridges of disposable media with minimum media area of 4.5 square feet per cell. Cartridges to be capable of proper operation at pressure differentials up to 75 psig and temperature to 250F. Furnish 3 sets of filter cartridges, two capable of removing 98% of solid particles 5 microns or larger and one capable of removing 98% of solid particles 75 microns or larger. To insure against by-passing, provide positive seal on each cartridges stack consisting of internal tie rod and seal nut arrangement, or equivalent. Single continuous cartridge per stack to be used.

2.6 FLOW CONTROL VALVES

A. Provide flow control valves pressure rated for 125 psi, containing lift check assembly which will automatically open by means of pump flow pressure, and automatically close when pump is not operating. Provide with means to manually open in case of pump failure.

B. Threaded Ends 2" and Smaller: Cast-iron body, bronze check mechanism, screw-in bonnet, straight or angle pattern.

C. Threaded Ends 2-1/2" through 4": Cast-iron body, bronze check mechanism, screw-in bonnet, straight or angle pattern.

2.7 LIQUID FLOW SWITCHES

A. Provide liquid flow switches as indicated to sense flow and non-flow. Construct of brass for all wetted parts, provide packless construction. Provide paddle with removable segments for pipe size and flow velocity. Provide vapor proof electrical compartment for switches mounted on cold piping hydronic systems. Furnish switches for 115 volt, 60 cycle, single phase with 7.4 amp. rating; or otherwise as indicated.

2.8 WATER RELIEF VALVES

A. Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, in accordance with ASME Boiler and Pressure Vessel Code.

B. Combined Pressure-Temperature Relief Valves: Bronze body, test lever, thermostat, complying with ANSI Z21.22 listing requirements for temperature discharge capacity. Provide temperature relief at 210F (99C), and pressure relief at 125 psi.

C. Pressure Relief Valves: Bronze body, test lever, A.S.M.E. rated. Provide pressure relief at 30 psi.

2.9 PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity as selected by installer to maintain operating pressure on boiler system.

B. Construction: Cast iron or brass body, low inlet pressure check valve, inlet strainer removable without system shut-down, non-corrosive valve seat and stem, factory set at operating pressure.

2.10 STRAINERS

A. Water:
1. Bronze Y-type strainers with stainless steel screens. 2 inches (50.8 mm) or smaller shall be screwed or sweat (water only), 400 psi WOG/300 psi SWP with 20 mesh screen, equal to Conbraco Series 59 BT/TBT, or Sarco.
2. 2-1/2 inches (63.5 mm) and larger shall be cast iron flanged, Class 125.

2.11 HYDRONIC SPECIALTIES

A. Air Vents
1. "Coin-Operated" equal to B&G No. 4V.
2. Automatic Float-Type Vent Valve: Taco Model 426, Watson McDaniel AV813W, Watts "Floatvent" FV4, or equal.

B. Diaphragm/Bladder Type Expansion Tanks: Provide minimum acceptance volume and tank volume as indicated on drawings.
1. Seven Gallons or Less: Amtrol "Extrol" combination unit with air purger and float-type vent. Amtrol 6000 series, charged at 12 psi.
2. Ten to 34 Gallons: ASME 125 psi construction, Amtrol AX diaphragm tank series, B&G D series, Taco CAX series, equal by Armstrong or Expanflex.
3. 37 Gallons and Larger: ASME 125 psi construction, full acceptance type, Amtrol L bladder tank series, B&G B series, Taco CA series, equal by Armstrong or Expanflex.

C. In-line Air Purgers (3 inches and Smaller):
1. Amtrol 400 series, B&G Model IAS, Taco 430 series, equal by Armstrong. Cast iron, 125 psi minimum.
2. Heavy duty air vent, Amtrol 720, B&G Model 107, equal by Taco or Armstrong. Cast iron, 150 psi minimum.
3. Combination separator/air vent, Spirotherm VJR or VSR.

D. Air Separators: ASME construction for working pressure as shown on the drawings with removable strainer and blow-down valve. Amtrol AS series, B&G "Rolairtrol," Taco ACF, Armstrong.VAS, Spirovent VSR.

PART 3 - EXECUTION

3.1 INSTALLATION OF UNIONS

A. Install unions adjacent to each valve, and at the final connection to each piece of equipment and elsewhere as indicated.

B. Install flanges in piping 2 1/2" and larger, where indicated adjacent to each valve, and at the final connection to each piece of equipment.

C. Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum).

D. Install dielectric fittings to connect piping materials of dissimilar metals in wet piping systems (water, steam).

3.2 INSTALLATION OF AIR VENTS

A. Provide at all high points of systems where required and/or shown on plans as follows:

B. All vents shall be manual type unless otherwise shown or specified.

C. Install vents so they are easily accessible. Provide access doors where required.

D. Install in tee at all high points of mains and risers. Provide 1-1/4" x 6" air collection chamber to which air vent is to be connected.

E. When piping is concealed, connect 1/2" copper tubing to collection chamber and mount manual valve near access door.

3.3 INSTALLATION OF STRAINERS

A. There shall be approved strainers in the inlet connection to each pump, and each automatic control valve, and elsewhere as shown on drawings. The intention is to protect by strainers all apparatus of an automatic character whose functioning would be interfered with by dirt or debris.

B. Provide approved valved dirt blow off connections for each strainer with the valve located 6" below strainer or as directed. Nipples and valves to be full size of strainer except 1" maximum size blow off tapping. For all strainers, the blow out connection is to terminate in an approved manner, at a point where there will be no risk of flooding or damage.

3.4 INSTALLATION OF WATER FILTERS

A. Install water filter in by-pass arrangement across system pumps. Allow clearance at top of filter for removal of cover and filter changes.

B. Install shut-off valves at filters and pressure gauges for measuring pressure drop across filters.

3.5 INSTALLATION OF LIQUID FLOW SWITCHES

A. Install liquid flow switches on inlet to water chiller, inlet to water condenser, and elsewhere as indicated. Install in horizontal pipe with switch mounted in tee on top of pipe with minimum of 24" of straight pipe with no fittings both upstream and downstream of switch. Remove segments of paddle to fit pipe in accordance with manufacturer's instructions.

B. Wiring of liquid flow switches is specified in applicable Division 16 sections; not work of this section.

3.6 INSTALLATION OF WATER RELIEF VALVES

A. General: Install on hot water generators, and elsewhere as indicated. Pipe discharge to floor. Comply with ASME Boiler and Pressure Vessel Code.

3.7 INSTALLATION OF PRESSURE REDUCING VALVES

A. Install as indicated, and in accordance with manufacturer's installation instructions.

3.8 INSTALLATION

A. General:
   1. Unless otherwise specifically indicated on the plans or specifications, all equipment and materials shall be installed in accordance with the recommendations of the manufacturer. Maintain maximum headroom and space conditions at all points.
   2. Fire Barrier Penetrations: Where pipes pass through fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity. Use fire stop caulking materials at all fire-rated wall penetrations.

B. Strainers:
   1. Install strainers at suction side of all HVAC pumps, ahead of all solenoid and automatic control valves (including at VAV terminal boxes) and where shown on plans.
   2. Install a ball valve with hose end and cap for blow-off on strainers.
   3. All strainer screens shall be removed, cleaned, and reinstalled after system pressure tests, cleanup, and startup is complete and before final acceptance. The strainers shall be marked for verification purposes after final cleaning and reinstallation.

C. Air Vents:
   1. Install manual air vents at high points of all piping consisting of a line size nipple – 6 inches long for an air collection chamber, pipe cap on top of nipple with 1/4-inch tap, 1/4-inch copper tubing with gauge cock. Locate gauge cock at accessible location and anchor to adjacent pipe or wall. Provide access panels as required for access.
   2. Install manual air vents at all heat transfer devices, coils, etc.

D. Hydronic Specialties:
   1. Install hydronic specialties of types and sizes as shown and/or scheduled on the plans.

E. Accessibility: Locate all equipment that must be serviced, operated, or maintained in fully accessible positions. Equipment shall include, but not be limited to, valves, cleanouts, motors, controllers, switchgear, and drain points. If required for better accessibility, furnish access doors for this purpose. Minor deviations from drawings may be made to allow for better accessibility.

END OF SECTION 232116

SECTION 232119 - POLYPROPYLENE HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods and specialty items for the following. Select product based upon operating temperature and pressures as follows:

1. Hot-water heating – 185F Operating Temperature, 100 PSI Pressure.
2. Chilled Water – 60F Operating Temperature, 125 PSI Pressure
3. Chilled Beam Water – 70F Operating Temperature, 125 PSI Pressure
4. Make-up water – 70F Operating Temperature, 100 PSI Pressure
5. Air Vent piping – 70F Operating Temperature, 100 PSI Pressure
6. Safety-Valve-Inlet and -Outlet Piping – As applicable
7. Air control devices – air separators / expansion tanks – As applicable

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 Specification sections apply to work of this section.

1.3 REFERENCE DOCUMENTS

A. ASTM F 2389-07 - Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

B. CSA B137.11 - Polypropylene (PP-R) Pipe and Fittings for Pressure Applications

C. NSF/ANSI 14 – Plastic Piping System Components and Related Materials

1.4 DEFINITIONS

A. Definitions shall be in accordance with local mechanical codes and ASTM F 2389.

1.5 SUBMITTALS

A. Material list naming each product to be used identified by manufacturer and product number.

1.6 QUALITY ASSURANCE

A. Material shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11.

B. Material shall comply with manufacturer’s specifications.

C. Special Engineered products shall be certified by NSF International as complying with NSF 14.

PART 2 - PRODUCTS

2.1 PIPE AND PIPING PRODUCTS

A. Pipe shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389 or CSA B137.11.

B. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in an extrusion process.

C. Hydronic hot water and heating piping shall contain a fiber layer (faser) to restrict thermal expansion.

D. All pipe shall comply with the rated pressure requirements of ASTM F 2389 or CSA B137.11. All pipe shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11.

2.2 FITTINGS

A. Fittings shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389.

B. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

C. All fittings shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11.

2.3 WARRANTY

A. Manufacturer shall warrant pipe and fittings for 10 years to be free of defects in materials or manufacturing. All warranties shall be provided to Owner by third party certificate upon substantial completion.

B. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.

C. Warranty shall be in effect only upon submission by the contractor to the manufacturer valid pressure/leak test documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

2.4 VALVES

A. Valves shall be manufactured in accordance with the manufacturer's specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11. The valves shall contain no rework or recycled thermoplastic materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

B. At the contractor's option, all valves may comply with other sections of the division 23 specifications, so long as proper factory transitions and or flanges are provided for proper installation.

2.5 SMOKE AND FIRE RATINGS

A. A Plenum-rated Piping System is required, all pipe located above ceiling shall be wrapped and/or insulated with standard fiberglass or mineral wool pipe insulation, field installed, with bare fittings no closer than every 6 ft. of pipe.

B. The pipe, wrap or insulation as a system shall meet the requirements of the division 23 insulation specifications and CAN/ULC-S102.2-03 or ASTM E84. The system shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.

2.6 UV PROTECTION

A. All pipe and fittings and accessories shall be protected from direct sunlight and other UV light sources. Any materials stored onsite for less than 30 days shall be covered per the manufacturer's requirements by tarp or other means and protected from exposure to directed sunlight for extended periods.

B. As part of the contractor's responsibilities, any piping expected to be exposed to direct UV light for more than 30 days, shall be provided with a Factory applied, UV-resistant coating or alternative UV protection. No exceptions.

2.7 THERMAL AND VAPOR BARRIER

A. Insulation materials furnished and installed hereunder should meet the minimum thickness requirements of American Society of Heating, Refrigeration, and Air Conditioning Engineers ASHRAE 90.1 (current edition), "Energy Efficient Design of New Buildings." However, if

other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor.

B. All pipe insulation shall comply with Division 23 specifications for pipe insulation. Contractor is responsibility for special fitting form enclosures, proper sizing for plastic piping and all elastomeric pipe insulation over plastic pipe.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Installers shall be trained and certified to install the pipe according to the manufacturer's guidelines. Contractor shall provide certificates of training for all installers of this piping prior to beginning work.

C. Install listed pipe materials and joining methods below in the following applications:

1. Underground Piping: Polypropylene (PP-R) piping in SDR 7.4, 9, 11, or 17.6 per manufacturer's instructions and ASTM D2774.

2. Aboveground: Polypropylene (PP-R) piping in SDR 7.4, 9, 11, or 17.6 based on the required minimum pressure rating and use temperature, in accordance with manufacturer's instructions and ASTM F2389.

D. Installation must be accomplished with the proper tools for installing piping following manufacturer's instructions.

E. Install hydronic piping level and plumb.

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

3.2 FUSION WELDING OF JOINTS

A. Install fittings and joints using socket-fusion, electrofusion, or butt-fusion as applicable for the fitting or joint type. All fusion-weld joints shall be made in accordance with the pipe and fitting manufacturer's specifications and product standards.

B. Fusion-weld tooling, welding machines, and electrofusion devices shall be as specified by the pipe and fittings manufacturer.

C. Prior to joining, the pipe and fittings shall be prepared in accordance with ASTM F 2389 and the manufacturer's specifications.

D. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

3.3 VALVE APPLICATIONS

A. Install butterfly valves close to the main on each branch and riser serving 2 or more equipment connections and where indicated.

B. Install butterfly or ball valves on the inlet to each equipment item and elsewhere as indicated.

C. Install drain valve at the base of each riser, at low points of horizontal runs, and where required to drain hydronic piping system.

D. Install swing check valve on the discharge side of each pump and elsewhere as indicated.

E. Install ball valves in each hot-water circulating loop and the discharge side of each pump.

3.4 PIPING INSTALLATIONS

A. Fire stopping shall be provided to both be compatible with the piping and meet the requirements of ASTM E 814 or ULC S115, "Fire Tests of Through-Penetration Firestops". Pipe insulations or fire resistive coating shall be removed where the pipe passes through a fire stop and, if required by the firestop manufacturer, for 3 inches beyond the firestop outside of the fire barrier.

B. Where the possibility exists that any pump will operate with no flow, the contractor shall provide temperature relief valve or comparable level of protection, set to a maximum temperature of 185F.

C. Heat tracing is required for exposed piping and should be installed on the pipe interior or exterior. It must be suitable for use with plastic piping and be self-regulating to ensure that the surface temperature of the pipe and fittings will not exceed 158F (70C).

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 230529 "Noise and Vibration Control."

B. Comply with requirements for pipe hanger, support products, and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps. All vertical pipe shall be provided with sleeves extended 2" above floor level to prevent leakage to floor below.

2. Individual, Straight, Horizontal Piping Runs:

a. Adjustable, steel clevis hangers.
b. Clamps on strut trapeze.
c. Clamps on strut attached to structure.
d. Clamps attached directly to the structure.

3. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor. For piping 2" (63mm) or smaller, install mid-story guides.

D. Install hangers and supports at intervals specified in the applicable Mechanical/Plumbing Code and/or as recommended by pipe manufacturer. Extended pipe saddle supports are permissible and shall be submitted with piping for review during shop drawing process. Any extended length shall be manufactured for specific use, not field fabricated.

E. Hangers and supports shall also be provided within 1-foot of every change of direction and within 1-foot of any pipe fittings and valves.

F. For hot water piping, provide clamps and supports that are felt or rubber/vinyl coated or lined.

G. For cold water piping supports and clamps may be bare metal. Ensure that the clamp or support does not have sharp edges that may scrape or gouge the piping.

H. Use care when installing riser clamps to not over tighten the clamps to cause indentation of the pipe. Riser clamps shall be isolated from the building structure by placing felt or rubber pads between the clamp and the structure.

I. All piping support materials shall be new and manufactured for the specific purpose of supporting systems, equipment, pipes and accessories. No improvised pipe support solutions shall be allowed.

J. Piping systems shall not have direct contact with the building structure. Provide isolation at pipes passing through studs, joists or plates. Use iron pipe sizes to fit pipe. Acceptable manufacturers for pipe/structure isolation:

1. Holdrite
2. Oatey
3. Sioux Chief

3.6 EXPANSION AND CONTRACTION

A. Provide expansion and contraction controls, guides and anchors to take into account the expansion and contraction of the pipe. Provide expansion loops or offsets as required and as indicated in the manufacturer's literature.

a. Install anchor points at least every 120 feet.
b. Install expansion loop or offset between each anchor point. Expansion device must be able to absorb all the stresses between the two anchor points. Refer to manufacturer's published instructions.
c. PPR pipes used for hot applications shall have expansion controls every 30 feet of straight runs.
d. Vertical risers of piping shall be anchored at each floor.
e. Provide anchor point at branch take-off in vertical riser of piping.

3.7 PRESSURE TESTING

A. While still accessible all piping shall be pressure/leak tested to the manufacturer's standards.

B. Tests shall be carried out using water. The test pressure shall be as indicated in the pressure leak testing procedures required by the manufacturer. But not less than 1.5 times maximum operating pressure or 125 psi whichever is less.

C. Any leaks detected shall be repaired at the contractor's expense by removing the leaking part and replacing with new parts welded per the pipe manufacturer's guidelines.

3.8 INSPECTING AND CLEANING

A. The pipes shall be flushed with cold water after finishing the installation. Flush the system until the water runs clear of debris and dirt.

B. Inspect and test piping systems following procedures of authorities having jurisdiction and as specified by the piping system manufacturer.

C. Clean and disinfect water distribution piping following procedures of the manufacturer and/or the authority having jurisdiction.

END OF SECTION 232119

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SECTION 232123 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

1.2 SCOPE

A. Pumps shall be factory tested, cleaned, and painted prior to shipment. Size, type, capacity, and electrical characteristics are listed in the pump schedule.

B. Insofar as possible, all pumps shall be by the same manufacturer.

PART 2 - PRODUCTS

2.1 PERMANENTLY LUBRICATED INLINE PUMPS

A. Permanently Lubricated Inline Pumps shall be Series PL as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.

C. The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic noryl impeller.

D. Pump shall have integral stainless steel face plate and double-sided stainless-steel neck rings for increased life and seasonal start-up capabilities.

E. Pump volute shall be of cast bronze. The connection style on bronze pumps shall be flanged with isolation valves.

F. The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.

G. Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.

H. Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.

2.2 CLOSED COUPLED INLINE PUMPS

A. Closed Coupled Inline Pump shall be Series 60 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. The pumps shall be of a vertical or horizontal installation type specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, all bronze construction. The pump internals shall be capable of being serviced without disturbing piping connections.

C. The pumps shall have a solid SAE1045 steel shaft that is integral to the motor. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.

D. The motor bearings shall support the shaft via heavy-duty grease lubricated ball bearings.

E. Pump shall be equipped with a mechanical seal assembly. Seal assembly shall have a brass housing, BUNA bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Pump shaft shall connect to a brass impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.

G. Pump should be designed to allow for true back pull-out access to the pump’s working components for ease of maintenance.

H. Pump volute shall be of cast iron design for heating systems or cast brass for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles.

I. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with the closed coupled pump design. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.

J. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.

K. Each pump shall be factory tested and name-plated before shipment.

L. Pumps shall conform to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR).

2.3 END SUCTION BASE MOUNTED PUMPS

A. End Suction Base Mounted Pumps shall be Series 1510 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.

B. Pumps shall be base mounted, single stage, end suction design with a foot mounted volute to allow servicing of the impeller and bearing assembly without disturbing piping connection. Pump volute shall be Class 30 cast iron with integrally cast pedestal support feet. The impeller shall be cast bronze enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.

C. The liquid cavity shall be sealed off at the pump shaft by an internally flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225°F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.

D. Baseplate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends, and securely welded cross members. Grouting area shall be fully open. A flexible type, center dropout design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupler shall be shielded by a coupler guard securely fastened to the base. Coupler shall allow for removal of pump’s wetted end without disturbing pump volute or movement of the pump’s motor and electrical connections.

E. Provide all pumps with neoprene couplers. EPDM shall not be acceptable.

F. High efficiency motor shall meet NEMA specifications and shall be of the size, voltage and enclosure 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 per Hydraulic Institute standards. It shall then be thoroughly cleaned and painted with at least one coat of high-grade machinery enamel prior to shipment.

G. Provide shaft guard with slotted window. Guard to be removable. Guard to meet ANSI B15.1, Section 8 and OSHA 1910.219 requirements.

H. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

I. Comply with pump and coupling manufacturers' written instructions.

J. A qualified representative of the pump supplier shall perform the pump alignment prior to start-up of any base mounted separately coupled pump. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."

K. After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

L. Alignment Tolerances: According to manufacturer's recommendations, but no more than ± .005" in the parallel and angular planes. Provide written report to Engineer and Owner from pump supplier indicating alignment procedure and readings from each pump installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases.
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: 5000 psi at 28 days.

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install check, shutoff, and throttling valves; check valve and throttling valve with memory stop; or triple-duty valve as detailed on discharge side of pumps as detailed.

E. Install Y-type strainer or suction diffuser as detailed and shutoff valve on suction side of pumps.

F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve.

H. Install check valve and gate or ball valve on each condensate pump unit discharge.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232500 – HVAC WATER TREATMENT, CLEANING FILLING, AND PURGING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SCOPE OF WORK

A. All field labor and materials required to install equipment and accomplish pre-cleaning and flushing operations of hydronic piping systems shall be furnished by mechanical contractor under the direct supervision of the general contractor. All field piping and start up/installation shall be considered part of the scope of work of the mechanical contractor.

1.3 INITIAL START-UP OF SYSTEMS

A. A start up meeting shall take place to coordinate work by and between contractor and supplier prior to filling of piping systems. A schedule shall be generated to allow for all work to be completed in a timely manner in accordance with plans and specifications.

B. All necessary permits governing discharge from hydronic piping systems to waste shall be provided by this contractor, and in place prior to introduction of any chemical into hydronic piping system. In addition, all drain connections should be completed to allow for proper discharge of chemically treated water to proper handling facility.

C. Hydronic systems shall not be filled until all water management equipment has been installed and is functional. This shall be verified by the water management service engineer assigned to project and notated on final certification documentation.

D. This Section includes water-management systems for the following:
   1. Chilled water piping (closed loop system)
   2. Hot water piping (closed loop system)

1.4 PERFORMANCE REQUIREMENTS

A. Base chemical treatment performance requirements on analysis of water quality available at project site. HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.5 SUBMITTALS:

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:
   1. Test equipment.
   2. Chemicals.

B. MSDS (Material Safety Data Sheet)/Products Bulletins: Required for all chemicals used on this project.

C. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Equipment data shall have manufacturer's name, rated capacities, sizes, dimensions, weights, loads, clearances, and field assembly requirements of all equipment required for an operational water management system for each hydronic piping system.

D. Wiring Diagrams: Detail power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

E. Water Analysis: Submit a copy of the raw water analysis to illustrate water quality available at Project site.

F. Procedural Bulletins: Technical procedures shall be submitted for all phases of startup of systems, including cleaning and treating of systems.

1.6 REPORTS/DOCUMENTATION:

A. Contractor shall provide a master water management program manual which shall include, at a minimum, MSDS, product bulletins, program log sheets, analytical reports, trend analyses, and emergency response bulletins for all chemicals. In addition, a copy of MSDS shall be left at each site where chemicals are to be used.

B. Supplemental inspections, lab work, and other technical support required shall be made part of this contract.

PART 2 - PRODUCTS

2.1 CLOSED SYSTEM WATER MANAGEMENT SYSTEM

A. Closed-Loop, Water Piping Chemicals: This inhibitor formulation shall be able to successfully protect against corrosive tendencies of closed loop water at project location. This product shall inhibit corrosion for systems with mixed metallurgies, including yellow metals. If necessary, a biocide shall be added to the closed loop piping system to prevent anaerobic bacterial growth. This biocide shall be compatible with all other chemical compounds in system.

2.2 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, bio-count, and inhibitors. All test apparatus shall be stored in a lockable test cabinet manufactured form corrosion resistant materials.

2.3 CHEMICAL CLEANING OF HYDRONIC PIPING SYSTEMS

A. Prior to operation of systems, all new chilled water and hot water piping shall be cleaned and flushed by mechanical contractor under the supervision of a qualified field service engineer from the water management company. All cleanout operations must begin with 24-48 hours of hydrostatic testing. Field engineer shall not certify cleanout(s) that have not been completed within this time frame. A planning report for pre-flush/flushing shall be provided to the Engineer 60 days prior to flushing this procedure may be witnessed by owner's representative. A final report shall be provided by the Division 23 contractor.

B. Cleanout shall be a two-step process incorporating the products and procedures to minimize extraneous dirt, oils, iron oxide, and other deleterious construction products from damaging HVAC piping and equipment.

2.4 ALKALINE CLEANOUT

A. This inhibited liquid alkaline compound with emulsifying agents and detergents will be able to remove light mill scale, cutting oils, pipe dope and other extraneous materials from the hydronic piping systems. If galvanized metal, aluminum, or any other metallurgy not compatible with alkaline cleaning chemistry is present, field service engineer must use alternative cleaning chemistry to preclude system damage.

B. Construction Mesh: Contractor shall ensure construction mesh is installed in pump strainers prior to clean-out.

C. Pre-flush: System to be cleaned shall be flushed to sanitary sewer for 24 – 48 hours with adequate flow to remove loose/suspended contaminants, using the largest accessible flush lines attached to low points of system. Flush all low points after pre-flush is complete.

D. Chemical Addition: Add chemicals to system in accordance with service engineer's instructions.

E. Cleaning: Circulate at least 24 hours throughout entire system with maximum achievable flow rate. System shall be continuously monitored by mechanical contractor during this process. Collect sample with cleaner mixed in system.

F. Drain and Flush: Drain and or flush system to sanitary to ensure system is turned over at least three times. Flush all low points, clean strainers, and remove construction mesh during this step. Ensure flush is complete in a timely fashion to prevent flash rust in system.

G. Final samples shall be drawn by service engineer to certify cleanout is complete. Provide certified report.

2.5 IRON CHELATING CLEANOUT

A. Immediately following hydrostatic testing and alkaline cleanout, and prior to placing any units, chillers, cooling towers, or boilers on-line, an Iron Chelating Cleanout shall be performed on each and all hydronic systems.

B. Construction Mesh: Ensure construction mesh is reinstalled in pump strainers prior to second clean-out.

C. Chemical Addition: Add chemicals to system in accordance with service engineers' instructions.

D. Cleaning: Circulate at least 24 hours throughout entire system with maximum achievable flow rate. System shall be continuously monitored by mechanical contractor during this process. Collect sample with cleaner mixed in system.

E. Drain and Flush: Drain and or flush system to sanitary to ensure system is turned over at least three times. Flush all low points, clean strainers, and remove construction mesh during this step. Ensure flush is complete in a timely fashion to prevent flash rust in system.

F. Final samples shall be drawn by service engineer to certify cleanout is complete.

G. Passivation: Immediately charge system with properly selected passivation material and or corrosion inhibitor to recommended level as directed by service engineer. Certify that all levels are in range for proper corrosion protection.

H. After successful completion of system clean outs, field service engineer shall immediately establish proper treatment residuals in all systems to prevent scale, corrosion, or biological deposits. All automatic water management equipment shall be fully operational at this time.

2.6 CONSTRUCTION PHASE

A. A letter of final certification shall be provided to the owner, architect, engineer, and mechanical contractor as to the fitness of all chemically treated hydronic systems.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

END OF SECTION 232500

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
3. DUCT INSULATION.
4. AIR DUCT ACCESSORIES
5. DIFFUSERS, REGISTERS & GRILLES

1.2 SCOPE

A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

B. Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.

C. Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4” above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not “dried-in”. If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

E. Provide a SMACNA duct cleanliness level “C” per the latest SMACNA standards.

PART 2 - PRODUCTS:

2.1 LOW VELOCITY DUCTWORK

A. Ductwork, plenums, and other appurtenances shall be constructed of one of the following: Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating. Aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14.

B. Ductwork, plenums, and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum.

ROUND DIAMETER	DUCT GAUGE	RECTANGULAR WIDTH	DUCT GAUGE
3-12 Inches	26 Ga.	3-12 inches	26 Ga,
12-18 Inches	24 Ga.	13-30 inches	24 Ga.
19-28 Inches	22 Ga.	31-54 inches	22 Ga.
29-36 Inches	20 Ga.	55-84 inches	20 Ga.
37-52 Inches	18 Ga.	85 inches and up	18 Ga.

C. All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations. Contractors shall ensure no exposed sharp edges or burrs on ductwork.

D. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.

E. All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.

F. Cross-break all ducts where either cross-sectional dimension is 18" or larger.

G. Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the Structural Engineer.

H. Double turning vanes shall be installed in square turns and/or where indicated.

I. INSULATED FLEXIBLE AIR DUCT: Thermaflex G-KM or equal. Flexible air duct shall be two (2) inch thick fiberglass insulation with CPE liner permanently bonded to a coated spring steel wire helix supporting a fiberglass scrim and fiberglass insulating blanket. Flexible air duct shall be listed under UL Standard 181 as a Class I flexible air duct complying with NFPA 90A and 90B. Maximum flame spread = 25 and maximum smoke developed = 50. Minimum insulating value is R-6.0. Flexible duct shall be used only for GRD runouts, and no section shall be more than five feet in length.

2.2 MEDIUM AND HIGH VELOCITY DUCTWORK

A. High velocity ductwork shall be utilized for all oval duct and supply ductwork between air handling units and VAV/CAV boxes. Provide Eastern Sheet Metal Model "CB" or equal takeoff fitting for each VAV/CAV off high velocity main. Shop or field fabricated takeoffs are not acceptable. Straight tees are not allowed.

B. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork, and manifolds. Drawings shall be available in an electronic format.

C. All round and oval high velocity ductwork for systems above 1.5" W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal as required by the latest SMACNA 10" W.G. Standard.

D. Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor. Ductwork shall be constructed of the following minimum gauges:

ROUND DIAMETER	DUCT GAUGE	FLAT OVAL MAJOR AXIS	DUCT GAUGE
3-14 Inches	26 Ga.	10-24 inches	24 Ga,
15-26 Inches	24 Ga.	25-48 inches	22 Ga.
27-36 Inches	22 Ga.	49-71 inches	20 Ga.
37-50 Inches	20 Ga.	71 inches and up	18 Ga.
52-84 Inches	18 Ga.		

E. All high velocity duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA 10" WG standard with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model "CB" or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges.

ROUND DIAMETER	DUCT GAUGE	FLAT OVAL MAJOR AXIS	DUCT GAUGE
3-50 Inches	20 Ga.	10-36 inches	20 Ga.
52-60 Inches	18 Ga.	37-60 inches	18 Ga.
61-84 Inches	16 Ga.	71 inches and up	16 Ga.

F. All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.

G. Duct dimensions indicated are required inside clear dimensions.

H. Ductwork shall be installed per the latest SMACNA Medium or High-Pressure Manual, whichever is applicable.

I. All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x¼" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

PART 3 - EXECUTION

3.1 GENERAL

A. Unless otherwise dimensioned on the drawings, all diffusers, registers, and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return, and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

B. All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15” wg. Apply per manufacturer's recommendations.

C. The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

D. Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

E. All fans and other vibrating equipment shall be suspended by independent vibration isolators.

F. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

G. Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

H. The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

I. All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

3.2 AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS

A. It is the intent of this section to ensure the ductwork installed has minimal air leakage. Air leakage testing shall be accomplished by an AABC certified company. Refer to the Test & Balance specifications. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.

B. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The Contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

C. All medium pressure ductwork between AHUs and VAV boxes shall be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume damper with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

D. A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor, and Insulation Contractor. At this meeting, the Contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.

E. It is the intent to test all medium pressure ductwork.

F. The maximum allowable outside air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5" WG. Therefore, if an outside air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 250 CFM. The maximum allowable exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50" WG.

G. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
   1. All ductwork as described in above paragraphs.
   2. Access doors
   3. Volume dampers
   4. End caps used to seal ducts
   5. Fire dampers

H. If any duct system fails a test, the Contractor shall reseal the system. It shall than be retested until the duct system meets the leakage allotment at no additional cost to the Owner.

END OF SECTION 233113

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SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
3. METAL DUCTS
4. DIFFUSERS, REGISTERS & GRILLES

1.2 SCOPE OF WORK

A. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

B. Ductwork accessories shall be constructed and installed per the latest edition of the International Mechanical Code.

C. Ductwork accessories shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4” above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not “dried-in”. If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

D. Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

E. Provide a SMACNA duct cleanliness level “C” per the latest SMACNA standards.

PART 2 - PRODUCTS

2.1 LOW VELOCITY DUCTWORK

A. Ductwork, plenums and other appurtenances shall be constructed of one of the following: Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating. Aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14.

B. Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum.

ROUND DIAMETER	DUCT GAUGE	RECTANGULAR WIDTH	DUCT GAUGE
3-12 Inches	26 Ga.	3-12 inches	26 Ga,
12-18 Inches	24 Ga.	13-30 inches	24 Ga.
19-28 Inches	22 Ga.	31-54 inches	22 Ga.
29-36 Inches	20 Ga.	55-84 inches	20 Ga.
37-52 Inches	18 Ga.	85 inches and up	18 Ga.

C. All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15" wg. Apply per manufacturer's recommendations. Contractors shall ensure no exposed sharp edges or burrs on ductwork.

D. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.

E. All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.

F. Cross-break all ducts where either cross-sectional dimension is 18" or larger.

G. Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the Structural Engineer.

H. Double turning vanes shall be installed in square turns and/or where indicated.

I. Provide a "high efficiency" type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.

J. Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

K. Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

L. The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

M. Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

N. All fans and other vibrating equipment shall be suspended by independent vibration isolators.

O. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

P. Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

Q. The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

R. INSULATED FLEXIBLE AIR DUCT: Thermaflex G-KM or equal. Flexible air duct shall be two (2) inch thick fiberglass insulation with CPE liner permanently bonded to a coated spring steel wire helix supporting a fiberglass scrim and fiberglass insulating blanket. Flexible air duct shall be listed under UL Standard 181 as a Class I flexible air duct complying with NFPA 90A and 90B. Maximum flame spread = 25 and maximum smoke developed = 50. Minimum insulating value is R-6.0. Flexible duct shall be used only for GRD runouts and no section shall be more than five feet in length.

S. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric; 20 oz. for low velocity ducts secured with snap lock.

T. TURNING VANES: Fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.

U. ACCESS DOORS IN DUCTWORK: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 2" thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils and downstream side of VAV boxes and CAV boxes.

V. ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24"x24" **(36"x36" Kees K where indicated)** in size and constructed with 16 gauge galvannealed steel for door and frame. Provide with primer finish to accept specified finish. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.

W. VOLUME DAMPERS (RECTANGULAR): Ruskin MD35 or Air Balance, Pottorff, rectangular volume dampers. Frames shall be 16-gauge galvanized steel. Blades shall be opposed blade 16-gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be ½" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

X. VOLUME DAMPERS (ROUND): Ruskin MDRS25 or Air Balance, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20-gauge steel and 6" long. Damper blades shall be 20 gauge crimped galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

Y. FIRE DAMPERS: Fire dampers shall be Ruskin 1BD2 1½ hour rating U-215B vertical 1½ hour rating or United Air Type U-255B for a 3-hour vertical rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3-hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20-gauge steel sleeves, angles, other materials, practices required to provide an installation to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. The blades shall be out of the air stream. Provide an access door for fire damper reset at all fire damper locations. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

2.2 HIGH VELOCITY DUCTWORK

A. High velocity ductwork shall be utilized for all supply ductwork between air handling units and VAV/CAV boxes. Provide Eastern Sheet Metal Model "CB" or equal takeoff fitting for each VAV/CAV off high velocity main. Shop or field fabricated takeoffs are not acceptable. Straight tees are not allowed.

B. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.

C. All round and oval high velocity ductwork for systems above 2" W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal as required by the latest SMACNA 3" W.G. Standard.

D. Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor. Ductwork shall be constructed of the following minimum gauges:

ROUND DIAMETER	DUCT GAUGE	FLAT OVAL MAJOR AXIS	DUCT GAUGE
3-14 Inches	26 Ga.	10-24 inches	24 Ga,
15-26 Inches	24 Ga.	25-48 inches	22 Ga.
27-36 Inches	22 Ga.	49-71 inches	20 Ga.
37-50 Inches	20 Ga.	71 inches and up	18 Ga.
52-84 Inches	18 Ga.		

E. All high velocity duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA 3" WG standard with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model "CB" or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges.

ROUND DIAMETER	DUCT GAUGE	FLAT OVAL MAJOR AXIS	DUCT GAUGE
3-50 Inches	20 Ga.	10-36 inches	20 Ga.
52-60 Inches	18 Ga.	37-60 inches	18 Ga.
61-84 Inches	16 Ga.	71 inches and up	16 Ga.

F. All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.

G. Duct dimensions indicated are required inside clear dimensions.

H. All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations.

I. Ductwork shall be installed per the latest SMACNA Medium-Pressure Manual, whichever is applicable.

J. All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x¼" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

K. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

L. Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panels at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

M. FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric. Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.

N. PRESSURE RELIEF DOORS: Provide a pressure relief door in the supply air ductwork at each air handling unit. It shall be located where shown on the drawings. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. The supply air relief door shall be Ruskin PRD18 or equal. Provide a vacuum relief door in the return air ductwork at each return air fan. It shall be located where shown on the drawings. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. The return air relief door shall be Ruskin NRD18 or equal. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct relief dampers shall be of the automatic resetting type.

O. ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24”x24” in size and constructed with 16 gauge galvannealed steel for door and frame. Provide with primer finish to accept specified finish. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.

P. ACCESS DOORS; IN DUCTWORK: All access doors in round or oval high velocity ductwork shall be screw and gasketed type. Screws shall be maximum 4 inches on centers.

DUCT DIAMETER	OPENING SIZE
3-4 inches	4"x10"
5-6 inches	6"x10"

DUCT DIAMETER	OPENING SIZE
7-24 inches	10"x16"
26-36 inches	16"x16"
Over 36 inches	16"x22"

Q. FIRE DAMPERS: Fire dampers shall be Ruskin 1BD2 1½ hour rating U-215B vertical 1½ hour rating or United Air Type U-255B for a 3-hour vertical rating. Other acceptable manufacturers are Air Balance or Pottorff. Fire dampers shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1½ or 3-hour fire protection rating as required by fire wall. Damper shall have a 165 degrees F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing minimum 20-gauge steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Blade and frame thickness shall be a minimum of 24 gauge. Installation shall be in accordance with the damper manufacturer's instructions. The blades shall be out of the air stream. Provide an access door for fire damper reset at all fire damper locations. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

2.3 EXPOSED ROUND DUCTWORK IN GYMNASIUM (OR OTHER AREAS NOTED ON THE DRAWINGS)

A. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.

B. Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.

C. Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Exposed metal shall be prepped and cleaned prior to painting. Coordinate with General Contractor. Ductwork shall be constructed as specified in LOW VELOCITY DUCTWORK.

D. Inner shell for spiral pipe shall be 26-gauge solid galvanized steel, as noted on drawings. Ductwork shall have 3 intermediate reinforcing ribs and be constructed of the minimum gauge specified.

E. Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.

F. The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75-degree F ambient temperature.

G. All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1-1/2" outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

H. All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

2.4 AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS

A. It is the intent of this section to ensure the ductwork installed has minimal air leakage. Air leakage testing shall be accomplished by an AABC or NEBB certified company. Refer to the Test & Balance specifications. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.

B. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The Contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

C. The entire outside air ductwork system shall be tested with some exceptions. On VAV systems, the high velocity ductwork upstream of the VAV boxes shall only be tested. Cap the duct at the inlet to the VAV box.

D. All exhaust air sheet metal ductwork associated with the outdoor air system shall be tested. Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

E. A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor and Insulation Contractor. At this meeting, the Contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.

F. It is the intent to test all ductwork. The duct systems which will require testing are as follows:
   1. All OA-1 thru 4 outside air duct systems.
   2. All OA-1 thru 4 exhaust air duct systems.

G. Do not insulate the supply air systems prior to testing.

H. The maximum allowable supply air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5" WG. Therefore, if a supply air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 250 CFM. The maximum allowable return air and exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50" WG.

I. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
   1. All ductwork as described in above paragraphs.
   2. Access doors
   3. Volume dampers
   4. Relief air doors
   5. Fire dampers
   6. End caps used to seal ducts

J. If any duct system fails a test, the Contractor shall reseal the system. It shall than be retested until the duct system meets the leakage allotment at no additional cost to the Owner.

2.5 KITCHEN RANGE HOOD EXHAUST DUCT

A. Ducts shall be constructed of 18-gauge stainless steel with liquid tight continuous external weld of all seams and joints where exposed. Where ducts are concealed, they shall be constructed of 16-gauge carbon steel with liquid-tight continuous weld of all seams and joints. Inside laps on duct joints shall project in a direction against the air flow.

B. Ducts shall be so constructed and sloped as to provide suitable drainage of grease to a collection point.

C. Hand holes for inspection and cleaning purposes, equipped with tight fitting sliding or swinging doors and latches, shall be provided in horizontal sections of exhaust ducts. Such openings shall be at the sides of the horizontal run in order to prevent dripping of residue. Spacing of such openings shall not exceed 20 feet and shall be located at all offsets. Openings shall have a minimum dimension of 20" in width with a height equivalent to the duct height minus one inch.

D. At the base of each vertical riser, a residue trap shall be provided with provisions for cleanout.

E. The Contractor shall install the kitchen rangehood exhaust duct systems and maintain the minimum code required clearances to combustibles. The use of UL listed and approved enclosure system of fire wraps/blankets installed per the manufacturer’s instructions are acceptable when required to achieve the clearance to combustibles requirements.

F. At the Contractor’s option, a UL2221 Pre-manufactured Duct System equal to Metal Fab 3G shall be acceptable. Duct shall have a stainless-steel inner liner, aluminized outer liner and one- or three-inch liner as required to comply with requirements of clearance to combustibles.

G. Shop drawings of the kitchen rangehood exhaust ductwork shall be made and submitted to the appropriate reviewing agency. Any fees associated with this submittal shall be borne by this Contractor.

2.6 DISHWASHER EXHAUST DUCT

A. All exposed exhaust duct shall be 18-gauge stainless steel duct with liquid tight continuous external weld of all seams and joints. All concealed exhaust duct shall be 20-gauge aluminum with liquid tight joints. Provide dielectric connection between steel and aluminum ductwork.

B. All ductwork shall be sloped so as to drain back toward the dishwasher.

2.7 DRYER VENT DUCTWORK

A. All dryer ducting shall be a minimum of 4" in diameter. Refer to the drawings for exact duct sizing.

B. Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. “Dryer ducts shall have a smooth interior finish and be supported at 4-foot intervals.” Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection.

C. Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4” 90-degree elbow and 4” 2.5 feet for every 45-degree fitting. These lengths may vary per local codes and dryer manufacturer’s recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.

D. Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.

E. Termination of dryer venting shall be to the exterior with a proper hood or roof jack equipped with a backdraft damper. Hood/jack shall be painted with suitable exterior grade paint and color per the Owner’s direction. Small orifice metal screening shall not be part of the hood or roof jack as this will trap lint and block the opening. The hood opening shall point down and maintain a minimum of 12 inches of clearance between the bottom of the hood and the ground or other obstruction.

PART 3 - EXECUTION

3.1 GENERAL

A. Unless otherwise dimensioned on the drawings, all diffusers, registers, and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return, and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

B. All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15” wg. Apply per manufacturer's recommendations.

C. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

D. The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

E. Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

F. Double turning vanes shall be installed in square turns and/or where indicated.

G. Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

H. All fans and other vibrating equipment shall be suspended by independent vibration isolators.

I. Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated.

J. Low Velocity Ductwork: Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.

K. The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

L. All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

END OF SECTION 233300

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SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Centrifugal roof ventilators.
2. Ceiling-mounted ventilators.
3. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on 1000’ above sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Acceptable Manufacturers: Greenheck, Twin City, Loren cook

B. PERFORMANCE: Fans shall be tested in accordance with AMCA 211 and AMCA 311 test codes for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air. Models shall be UL 705 listed.

C. CONSTRUCTION: Fan housings shall be constructed of spun aluminum and shall offer finish durability and aesthetic appearance. Fan spinnings shall have a rolled bead edge for rigidity. All units have a deep venturi inlet to prevent snow and rain entry into the building. The curb cap shall include prepunched mounting holes for ease of installation. A conduit chase constructed of electrical metallic tubing shall be provided to the motor compartment. The curb base shall have continuously welded corners for maximum leak protection. Lifting lugs shall be provided inside the motor compartment for ease of handling and installation. Fans shall bear a permanently attached nameplate displaying model and serial number of the unit for future identification. Housing shall be upblast or downblast as scheduled.

D. DIRECT-DRIVE UNITS: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing

E. BELT-DRIVEN UNITS: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

F. WHEEL: Fan wheels shall be of the centrifugal backward inclined type, constructed of aluminum and containing a matching inlet venturi for optimum unit performance. Wheels shall be statically and dynamically balanced.

G. SHAFT: Fan shafts shall be precision-ground and polished. Shafts shall have a first critical speed of at least 125% of the fan’s maximum operating speed.

H. BEARINGS: Bearings shall be of the one-piece, pillow block type with relubricable zerk fittings. Bearings shall be designed for air handling service with a minimum L-10 life in excess of 100,000 hours; L-60 500,000 hours at the maximum cataloged operating speed. Bearing mounting plate shall have self-aligning tabs for exact locating and alignment of bearings.

I. MOTOR: Motors shall be of the heavy-duty ball bearing type, closely matched to the fan load. A disconnect switch shall be factory installed and wired to the fan motor as standard. Motor shall be mounted on the outside of the unit, isolated from the airstream. All motors shall be UL recognized.

J. DISCONNECT SWITCH: Where scheduled, a NEMA 1 disconnect switch shall be supplied with wiring leading from the motor to the junction box (ODP and TEFC motors).

K. ACCESSORIES: Backdraft damper, 16" roof curb, curb hinge with retaining chain, and aluminum bird screen. Refer to the drawings for additional requirements.

2.2 CEILING-MOUNTED VENTILATORS

A. Acceptable Manufacturers: Greenheck, Twin City, Loren cook

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 IN-LINE CENTRIFUGAL FANS

A. Acceptable Manufacturers: Greenheck, Twin City, Loren cook

B. PERFORMANCE: Fans shall be tested in accordance with AMCA 211 and AMCA 311 test codes for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air. Models shall be UL 705 listed.

C. CONSTRUCTION: Unit exterior shall be constructed of heavy gauge galvanized steel. The fan housing shall be square in shape and readily attachable to building ductwork. Unit side panels shall be removable for easy access for maintenance and service. The power assembly shall be removable as a complete module through the side access panel. Fan housings shall have universal mounting brackets to accommodate horizontal or vertical installations. Fans shall bear a permanently attached nameplate displaying model and serial number of the unit for future identification.

D. WHEEL: Fan wheels shall be of the non-overloading centrifugal backward inclined type, constructed of aluminum and containing a matching inlet venture for optimum unit performance. Wheels shall be statically and dynamically balanced.

E. MOTOR: Motors shall be of the heavy-duty ball bearing type, closely matched to the fan load. A disconnect switch shall be factory installed and wired to the fan motor as standard. Motor shall be mounted on the outside of the unit, isolated from the airstream. All motors shall be UL recognized.

F. DISCONNECT SWITCH: Where scheduled, a NEMA 1 disconnect switch shall be supplied with wiring leading from the motor to the junction box (ODP and TEFC motors).

G. 50.7 ACCESSORIES: Unit-mounted speed controller, backdraft damper, double-wall insulated, foil faced insulated. Hanging kit with vibration isolators at all four corners. Refer to the drawings for additional requirements.

2.4 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 07 for installation of roof curbs.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

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SECTION 233600 –AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor’s attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer’s temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor’s attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. ETI, Trane, Titus, Daikin, Carrier, JCI/York, Price.

2.2 GENERAL

A. Terminals shall be certified by ARI and bear the ARI 880 seal.

B. Terminals shall be constructed of not less than 22 gauge galvanized steel, able to withstand a 125 hour salt spray test per ASTM B-117. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable). Terminal shall include control enclosure and hanger brackets. The terminal shall be provided with a removable bottom access panel.

C. Casing shall be insulated with ½" thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be 0.24 (BTU · in) / (hr · ft² · °F). Insulation must meet all requirements of ASTM C1071 (including C665), UL 181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A. Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. Simple "buttering" of raw edges with an approved sealant is not acceptable. Insulation shall be covered with scrim backed foil facing. All insulation edges shall be covered with foil or metal nosing. Insulation shall meet ASTM C1136 for mold, mildew, and humidity resistance. All appurtenances including control assemblies and control enclosures, shall not extend beyond the top and bottom of the unit casing. At an inlet velocity of 2000 f.p.m., the static pressure drop across the basic terminal shall not exceed .08" W.G. for all unit sizes.

D. Additionally, the air terminals shall be double wall insulated, foil faced.

E. The primary air valve shall consist of a minimum 22-gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper actuator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3" W.G. inlet pressure.

F. The differential pressure airflow sensor shall traverse the duct along two perpendicular diameters. Cylindrically shaped inlets shall utilize the equal cross-sectional area or log-linear traverse method. Single axis sensor shall not be acceptable. A minimum of 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure

chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" W.G. at an air velocity of <450 FPM. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements. Terminal shall have access door for inspection and cleaning.

G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.08 inch. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

PART 3 - EXECUTION:

3.1 GENERAL

A. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists.

B. A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.

C. Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

D. Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

E. The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

F. Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

G. Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

H. EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative.

END OF SECTION 233600

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SECTION 233713 - DIFFUSERS, REGISTERS & GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. The Contractor’s attention is directed to the following Plans and the Specification Sections:
1. SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC
2. IDENTIFICATIONS FOR HVAC PIPING AND EQUIPMENT
3. DUCT INSULATION.
4. METAL DUCTS

PART 2 - PRODUCTS

2.1 REGISTERS, GRILLES, AND DIFFUSERS

A. Acceptable R, G & D manufacturers are Krueger, Anemostat, Nailor Industries, Titus and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes for specified devices shall be selected by the Architect. Factory color samples shall be submitted with shop drawings. Devices shall be white unless noted otherwise. Aluminized steel devices are not acceptable. Steel devices are not acceptable unless specifically noted otherwise.

B. Refer to drawings for schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated on drawings, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 236126 - SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set(s) for each air-handling unit.
   2. Fan Belts: One set(s) for each air-handling unit fan.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For Complete Unit: One year from date of Substantial Completion.
      b. For Compressor: Five year(s) from date of Substantial Completion.
      c. For Parts: One year from date of Substantial Completion.
      d. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Trane; a business of American Standard companies.
   2. Daikin AC
   3. Mitsubishi
   4. Carrier
   5. York/JCI

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Concealed Evaporator-Fan Components:
1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch; leak tested to 300 psig underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Motors and Electrical Work."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Filters: Permanent.
10. Condensate Drain Pans:
    a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
       1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1
       2) Depth: A minimum of 2 inches deep.
    b. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
       1) Minimum Connection Size: 3/4”.
    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
    e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Floor-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
   a. Discharge Grille: Aluminum with surface-mounted frame
   b. Insulation: Faced, glass-fiber duct liner.
   c. Drain Pans: Galvanized steel, with connection for drain; insulated.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.

3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Belt drive, centrifugal
5. Fan Motors:
    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Motors and Electrical Work."
6. Air Filtration Section:
    a. General Requirements for Air Filtration Section:
        1) Comply with NFPA 90A.
        2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
        3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
    b. Extended-Surface, Panel Filters:
        1) Factory-fabricated, dry, extended-surface type.
        2) Thickness: 1 inch.
        3) Arrestance according to ASHRAE 52.1: 20.
        4) Media-Grid Frame: Galvanized steel
        5) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. Wall-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Motors and Electrical Work."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Enclosure Type: Totally enclosed, fan cooled.
    d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
    e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    f. Mount unit-mounted disconnect switches on interior of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

7. Condensate Drain Pans:
   a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
      1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1
      2) Depth: A minimum of 1 inch deep.
   b. Single-wall, stainless-steel sheet.
   c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
      1) Minimum Connection Size: 3/4".
   d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
8. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
      3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
   b. Washable Panel Filters:
      1) Factory-fabricated, viscous-coated, flat-panel type.
      2) Thickness: 1 inch.
      3) Arrestance according to ASHRAE 52.1: 20.
      4) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:
   1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
   2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
      a. Compressor Type: Scroll.
      b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
      c. Refrigerant Charge: R-407CR-410A
      d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240.
   3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
   4. Fan: Aluminum-propeller type, directly connected to motor.
   5. Motor: Permanently lubricated, with integral thermal-overload protection.
   6. Low Ambient Kit: Permits operation down to 0 deg F.
   7. Mounting Base: Concrete.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230900 "Controls and Instrumentation " and Section 230593 "Testing, Adjusting, and Balancing for HVAC."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
   1. Thermostat shall be hard wired, installed on the wall. Wireless controllers are not acceptable.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

2.5 EQUIPMENT SUPPORTS

A. Equipment Supports: Internally reinforced perimeter or Tail-type metal equipment supports as indicated on drawings, capable of supporting superimposed live and dead loads between structural supports, including equipment loads and other construction indicated on drawings, spanning between structural supports; capable of meeting performance requirements; with welded corner joints and integrally formed structure-mounting flange at bottom.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
      a. AES Industries, Inc.
      b. Curbs Plus, Inc.
      c. Greenheck Fan Corporation
      d. LMCurbs
      e. Pate Company (The)
      f. Roof Products and Systems (RPS); a division of Hart & Cooley, Inc.
      g. Thybar Corporation

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

C. Suported Load Capacity: As indicated on drawings.

D. Material: Zinc-coated (galvanized), aluminum-zinc, alloy-coated steel sheet, not less than 0.064 inch thick.
   1. Finish: Two coat fluoropolymer
   2. Color: White

E. Material: Aluminum sheet, not less than 0.090 inch thick.
   1. Finish: Two coat fluoropolymer
   2. Color: White

F. Construction:
   1. Curb Profile: Profile as indicated on drawings compatible with roofing system.
   2. Insulation: Polyisocyanurate board.

a. R-Value: 12.0 according to ASTM C 1363.

3. Liner: Same material as equipment support, of manufacturer's standard thickness and finish.
4. Nailer: Factory-installed continuous wood nailers 3-1/2 inches wide under top flange on side of curb, continuous around support perimeter.
5. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb of size and spacing required to meet wind uplift requirements.
6. Platform Cap: Where portion of equipment support is not covered by equipment, provide weathertight platform cap formed from ¾-inch thick plywood covered with metal sheet of same type, thickness and finish as required for curb.
7. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support.
8. Fabricate equipment supports to minimum height of 12 inches above roofing surface unless otherwise indicated.
9. Sloping Roofs: Where roof slope exceeds 1:48, fabricate each support with height to accommodate roof slope so that tops of supports are level with each other. Equip supports with water diverters or crickets on sides that obstruct water flow.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch-thick, reinforced concrete base that is 4 inches larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Division 09. Coordinate anchor installation with concrete base.

D. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install seismic restraints.

F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

G. No condensing units shall be installed indoors.

H. Condensing units shall be connected to concrete pads with the perimeter of the base fenced. Maintain the manufacturer's minimum clearance requirements as well as the NEC requirements (whichever is more stringent).

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Ductwork." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Pressure test shall be verified by the Commissioning Agent.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 236126

SECTION 237040 - DUCTLESS SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The provisions of the Instructions to Bidders, General and Supplementary Conditions, shall govern the work under this Division or Section the same as if incorporated herein. The attention of the Subcontractor of this Divisions or Section is directed to the Instructions to Bidders concerning substitution of materials and equipment.

B. Division 26 documents shall apply with regard to the installation and termination of power wiring.

1.2 DESCRIPTION OF WORK

A. Furnish and install split system air conditioners complete with all accessories as described in these specifications and on the project drawings.

B. Split system air conditioners shall be complete systems with indoor air handling unit, outdoor unit, and controls. Air handling unit and outdoor unit shall be by the same manufacturer.

C. Contractor shall furnish and install the equipment described below as specified, unless his product cannot meet a stated requirement. In that case only, the submittals shall list specifically any and all exceptions to this specification, with explanation, proposed alternative, and effect on pricing and/or performance, if applicable.

1.3 QUALITY ASSURANCE

A. Equipment shall be certified as being in compliance with American Refrigeration Institute (ARI) standard(s) for that type of equipment.

B. Conform to NFPA 90A for the installation air conditioning unit and references.

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

1.4 WARRANTY

A. Warranty: The indoor and outdoor units shall be furnished with full coverage warranty against defects in materials and workmanship for any and all failures except failure due to misuse or external damages. Warranty on the complete unit shall be for one year from date of acceptance by the owner (date of start-up with acceptable operation). On the compressors, the warranty shall be extended for four years, for a total of five years from date of acceptance by owner.

PART 2 - PRODUCTS

2.1 SYSTEM

A. Split system air conditioners shall be packaged system complete with indoor air handler equipped with supply air fan(s), cooling coil, and outdoor unit equipped with condensing coil, outdoor fan, and compressor.

B. The indoor and outdoor units shall be of the same manufacturer with certified performance from the manufacturer. Acceptable manufacturers are Trane, Mitsubishi, Daikin, Samsung, LG.

C. The matched system shall be certified by the manufactured to be in compliance with the requirements of International Energy Code.

D. All system components shall be UL listed.

E. Provide written instructions; include set point changing, in an operator's manual. Mini-splits will not be monitored from the BAS. A separate room thermostat in each room served by a mini-split will be monitored by the BAS.

F. System must be supplied with and designed for refrigerant that has a global warming potential (GWP) below 700.

2.2 INDOOR UNIT

A. Product Description: Ductless type evaporator for high wall / mounting shall be provided with remote wall mounted infrared compatible controls.

B. Controls/Components:
   1. Controls and components include:
      a. Relays and connections for condensing unit.
   2. Unit mounted Digital Controls:
      a. Thermostat-post purge fan control
      b. Fan speed control with auto ramping
      c. Straight Cool compatible (dipswitch setting)
      d. Digital Set Point and room temperature display
      e. Cycling or constant fan modes
      f. Hanger mounting kit
   3. Installer Supplied Items:
      a. Power wiring
      b. Low voltage wiring
      c. Mounting screws, fasteners
      d. Refrigerant piping (if not supplied)
      e. Condensate piping

2.3 OUTDOOR UNIT

A. Condensing units shall be air-cooled, high efficiency units.

B. The SCC/SHC condensing units shall provide cooling and heating for a single evaporator.

C. Provide 24V control interconnection to the evaporator. All valves shall be internal to reduce tampering. All units shall be equipped with a large capacity suction accumulator with surge baffles and enhanced oil management, a factory installed, solid core filter drier, and loss of refrigerant charge protection. Crankcase heater shall be installed as a part of the low ambient control.

D. A 0°F compressor cut-out is fitted for maximum system reliability.

E. Capacities/Efficiency: Unit shall produce system SEER2's exceeding 14.0.

F. Cabinet Construction:
1. Fabricated of G60 galvannealed steel.
2. Finished in off white with corrosion inhibiting, polyester, powder-coated paint (2000 hour salt spray-tested)

G. Fan Guard: Integral to Cabinet.

H. Compressor: Hermetically sealed, high efficiency rotary or reciprocating type, depending on unit capacity. Motor is PSC type with internal overload protection. Compressor is installed on resilient mountings.

I. Refrigeration Circuit: Provide a pre-charged refrigerant for the condenser coil and evaporator. Charging of the field installed piping is required. Unit refrigeration valves shall be solid brass, for sweat connection.

J. Condenser Coil: Condenser coil is seamless, copper tubing, arranged in staggered configuration, with enhanced aluminum fins. The tubes are mechanically expanded for secure bonding to fin shoulder.

K. Condenser Fan/Motor: The condenser fan is a large diameter, high efficiency, three blade propeller type, directly connected to the totally enclosed 8 pole, ECM motor. The motor is fitted with internal thermal protection. Units shall be draw-through air flow design.

L. Controls/Components: Compressor and Fan Motor Contactor
1. Capacitor
2. Loss of charge switch (9-15 only)
3. Low voltage transformer
4. Low voltage interconnect
5. Large capacity suction accumulator
6. Defrost control board and termination switch
7. Factory installed solid core filter drier
8. Low ambient option shall be provided to operate in cooling mode at outside temperatures below 20°F.

PART 3 - EXECUTION

3.1 OUTDOOR UNIT INSTALLATION

A. Split system outdoor units shall be installed according to manufacturer's recommendations regarding refrigerant line sizes, routing, drip legs, double risers, traps, etc.

B. The outdoor unit shall be installed on a roof mounted support curb, per the detail, and located such that the manufacturer's recommended clearances for service and proper air flow are met.

C. Coordinate with the requirements listed under Division 26 for the installation of unit disconnect. Provide supervision and coordination to assist in the termination of power wiring specified under Division 26.

3.2 AIR HANDLER INSTALLATION

A. Install the air handler level with clearance for service in accordance with the manufacturer's recommendations.

B. Coordinate with the requirements listed under Division 26 for the installation of unit disconnect. Provide supervisions and coordination to assist in the termination of power wiring specified under Division 26.

3.3 START-UP

A. Operate the air handler and outdoor unit and check the operation of all controls.

B. The unit shall be fully inspected and cycled through all operating modes by the start-up technician. Upon request a start-up report shall be provided to the architect/owner/engineer. As a minimum, the start-up report shall include operating charge, amperage, and voltage.

END OF SECTION 237040

SECTION 237313.13 – INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Contractor's attention is directed to the General and Special Conditions, COMMON WORK RESULTS FOR HVAC and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section, and which are hereby made a part of the work specified in this section.

B. Each Contractor’s attention is also directed to Specification Section SHOP DRAWINGS, MAINTENANCE, MANUALS AND PARTS FOR HVAC, and provide all documentation called for therein.

C. Each Contractor’s attention is also directed to Specification Section INSTRUMENTATION AND CONTROLS FOR HVAC to determine controls, including variable frequency drives, to be furnished. Where manufacturer’s temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.

D. Each Contractor’s attention is also directed to Specification Section VARIABLE FREQUENCY MOTOR CONTROLLER to determine VFDs to be furnished by the contractor.

E. Each Contractor’s attention is also directed to Specification Section TESTING, ADJUSTING, AND BALANCING FOR HVAC. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

1.2 SCOPE

A. The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected, and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

B. All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer’s installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer’s installation requirements whether specifically detailed or not within the Plans and Specifications.

C. All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion.

D. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Trane, Daikin, Greenheck, AAON, JCI/York.

2.2 GENERAL

A. Provide factory built and factory tested air handling units of sizes, capacities and configurations as scheduled and as specified herein.

2.3 CASINGS:

A. Unit shall be double wall foam injected constructed in all sections. Foil facing on insulation shall not be acceptable as a substitute for double wall construction. Insulate all sections with 2" thick foam injected insulation, 1 ½ lb. per cubic foot density. All panels shall be solid on the interior and exterior. Insulation shall comply with NFPA 90A. Fiberglass insulation shall not be acceptable.

B. Interior and exterior panels and structural frames shall be constructed of G90-U galvanized steel. Casings with welds on interior and exterior surfaces that have burned through to exterior surfaces shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel.

C. Construct casing sections located upstream of the supply fan for operation at 4 inches water gauge negative static pressure and casing sections located downstream of the supply fan for operation at 6 inches water gauge positive static pressure.

D. All joints between exterior panels and structural frames shall have seals and gaskets with closed-cell foam gasketing for air seal and acoustical break.

E. As required for routine service access, unit shall be supplied with full height, galvanized, double wall, hinged, removable access doors. Access door shall have a full perimeter automotive type gasket to prevent air leakage, and Ventlock style handle that can be opened from unit interior. Doors shall open against system pressure. If access doors open against unit operating pressure, provide safety latches that allow access doors to partially open after the first handle movement and fully open after second handle movement. All handles shall operate easily without special tools.

2.4 FAN ARRAYS:

A. Fans shall be aluminum airfoil, Class III, direct drive arrangement and shall be individually housed. Fans shall be certified by AMCA for performance. Fan shall be housed in a "cell".

B. Fan housing or "cell" shall be constructed of aluminum with perforated inner liner, melamine insulation, with solid outer panels.

C. Fan/motor assembly shall be mounted within the housing on an adjustable slide rail base. Fan/motor assembly must be capable of either horizontal or vertical application.

D. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, for fan application class BV-5, to meet or exceed a rotational imbalance Grade G.55, producing a maximum rotational imbalance of .022" per second peak, filter in (.55mm per second peak, filter in). "Filter in" measurement indicates that the specified balance grade must be achieved at the submitted design operating speed for the fan(s). Fan and motor assemblies submitted for approval incorporating larger than 215T frame shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .022" per second peak filter in (.55 mm per second peak, filter in).

E. Fan and motor assemblies shall be designed for application in multiple fan arrays.

F. Fan Backdraft Dampers:
   1. Each fan applied in multiple fan applications shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan, or multiple fans, becomes disabled. The system effect for the submitted back flow prevention device shall be included in the calculation to determine the fan TSP for fan selection purposes and shall be indicated as a separate line item SP loss in the submitted fan selection data. Manufacturers other than the basis of design being submitted must provide independent lab certification of fan testing that indicates the system effects attributed to the submitted back flow prevention device in the submitted close coupled mounting arrangement at the inlet of the fan. Fans submitted with discharge dampers will not be approved.
   2. Back Draft Damper performance data that is based on an AMCA ducted inlet and ducted discharge mounting configuration will not be accepted. Submitted Back flow prevention device data must be reflective of close coupled mounting at the intake of the fan(s) per the project design documents. Motorized dampers or other motorized devices submitted for back flow prevention are not acceptable.
   3. AHU Manufacturers that do not manufacture the fans being submitted must provide tested and certified performance data for fans as installed in the AHU unit including the back draft damper system effects introduced by close coupled back draft dampers at the fan inlet.

G. Motors:
   1. All motors shall be standard foot mounted type, TEFC or TEAO motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere.
   2. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2.
   3. Motors shall be as manufactured by Baldor, Siemens, or Toshiba. Motors shall be available in 1/2 HP increments at nameplate HP ratings from 1.5 HP through 12 HP.
   4. All motors shall include permanently sealed bearings and shaft grounding means to protect the motor bearings from electrical discharge machining due to stray shaft current.

Motors provided with hybrid ceramic bearings, when specified, do not require shaft grounding devices.

5. Motors shall be 3 phase ODP with NEMA frame and 1.15 service factor. Motor base shall be adjustable. Motor brake horsepower shall not exceed scheduled values. Fan brake horsepower shall not exceed 85% of motor horsepower. All motors shall comply with EPACT efficiency requirements. Refer to Specification Section – ELECTRIC MOTORS, ETC. for more requirements. Fan sections controlled by variable frequency drives and shall be factory installed. Refer to Specification Section - CONTROLS for all VFD specification requirements.
6. One VFD shall control two supply fans. One VFD shall control two return fans.

H. Control Panel:
1. As required by system design, provide short circuit protection for each motor circuit through means of using fuses with fuse blocks or circuit breakers.
2. Provide three phase power distribution wiring and control wiring as required. All three phase power components shall have a rating listed for Short Circuit Current Rating. Provide control wiring and components required for complete operation of fan wall system.
3. All components shall be mounted in a NEMA 12 enclosure.
4. Provide fan sections with fan type as specified on drawings designed and suitable for class or service indicated. Fan sections shall have full height, double wall hinged, removable access doors on drive side for inspection and maintenance of internal components. Fan sections with plug fans shall have galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened.

I. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with a minimum of 2-inch spring isolators. Provide adjustable motor base, adjusted with mounting bolts, to provide variation in center distance. Provide locking nuts, or similar devices, to secure base in proper position. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. Fan and motor assembly shall be weighed at the manufacturer’s factory for isolator selection. Vibration shall be measured at each fan shaft bearing in horizontal, vertical, and axial directions. All fans shall have pillow block bearings with minimum L-50 200,000 hour rating. Provide grease lubricated fan bearings with externally accessible fittings for lubrication. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.

2.5 COIL SECTIONS AND DRAIN PANS:

A. Provide double wall casing for coil sections. Inside surfaces exposed to the air stream shall be constructed of stainless steel. Design internal structure of coil section to allow for removal of coils. Provide suitable baffles to ensure no air bypass around coils. Condensate drain pans and coil casing and all fasteners shall be constructed of stainless steel. Insulate coil section casings and drain pans as prior specified.

B. All coils shall be tested at 200 psig air pressure while submerged in water. Coil performance shall be certified in accordance with ARI Standard 410. All coils shall have stainless steel casings. Construct coil headers of round copper pipe or cast iron. Clearly label supply and return headers on the outside of the units such that the direction of coil water flow is counter to the direction of air flow. If two or more coils are stacked in the unit, install intermediate drain pan channels between the coils to drain condensate to main drain pans without flooding lower coils or passing condensate through the air stream.

C. Provide type 304 sealed stainless steel drain pans. Encase insulation between exterior and interior walls. Drain pans shall be sloped in two planes; cross break interior pans and pitch toward drain connections to ensure complete condensate drainage. Drain pans shall be installed under the complete cooling coil section. All drain pan connections will be to the side of the unit to ensure proper trapping. Units without 2-way sloped drain pans shall coat drain pans with anti-microbial treatment.

D. A 20 gauge, reinforced sheetmetal baffle shall be field or factory provided across the top of the entire coil protected with a freeze-stat. Baffle shall be full width of unit and 24" minimum in length. The purpose of the baffle is to prevent nuisance freeze-stat trips from cold air passing over the top of the coil near the freeze-stat.

E. DAMPERS: Provide internally mounted ultra-low leak outside air dampers as specified on drawings. Dampers shall be double-skin airfoil design. Construct damper blades and damper frames of galvanized steel. Blades shall rotate on stainless steel sleeve bearings. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge and 9 CFM/square foot at 4 inches water gauge.

F. PREFILTERS: Filters shall be 2" thick, 30% efficient Merv 8, pleated and disposable. The filter pressure drop shall be 0.28" at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2. Provide filter boxes with either hinged access doors at each end. Provide racks to receive filters in either flat or angle type pattern. Provide air filters to fit in filter box of the type scheduled on the drawings. Sizes and quantities shall be per the manufacturer's recommendations.

G. FILTERS: Filters shall be MERV 13 - minimum 12" thick, efficient deep pleated, rigid, disposable cartridge or bag filter. The filter pressure drop shall be 0.47" at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. Each filter shall consist of high density microfine glass fiber media laminated to a non-woven synthetic backing to form a lofted filter blanket, media support grid, contour stabilizer and enclosing frame. The filter media shall have an average of on the ASHRAE Test Standard [52-76] and an average arrestee of not less than 99% on that standard. Filters shall be listed by Underwriters' Laboratories as Class 2. Provide filter boxes with either hinged access doors at each end. Provide racks to receive filters. Provide air filters to fit in filter box of the type scheduled on the drawings. Sizes and quantities shall be per the manufacturer's recommendations. Provide a clean set installed at substantial completion and a spare set for the Owner's use.

H. Disposable Filter Media: Filter Media shall be 2" thick fiberglass Air Filter Media Pads with an initial maximum pressure drop of 0.20" wg @ 500 fpm.

I. Retainer Frame and Backing Wire Frame: Provide for each filter to support the disposable filter media. Products shall be factory assembled. Retainer Frame shall be 10 gauge minimum and shall be provided with additional angled support prongs to prevent sagging filter pad. Frame shall be 18 gauge minimum and shall have flush mitered corners. Frames shall also be provided with 16 gauge galvanized 1x1 welded wire support backing.

2.6 ELECTRICAL AND CONTROLS:

A. All internal electrical components shall be factory wired for single point power connection. Units with electric reheat will be wired with independent power supply. All electrical components shall be UL Listed, Approved, or Classified where applicable and wired in compliance with the National Electrical Code. Weatherproof, integral door interlocking disconnect switch, motor starters, control circuit fusing, control transformer for 24 VAC circuit, and terminal strip shall be supplied as standard components in the control center. Motor starters consist of a contactor and adjustable overload protection and shall be provided for all motors in the unit.

B. NEMA 3R door disconnect, controls transformer, motor starters, dial type adjustable overloads, frost control inlet air sensor and timed exhaust control sequence, mild outside air economizer control sequence, motorized low leak dampers to close the outside air intake and exhaust air relief when the unit is not in operation.

PART 3 - EXECUTION

3.1 GENERAL

A. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform startup by their factory authorized technicians and shall complete and submit start-up reports/checklists.

B. Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.

C. Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation, and easily maintained at the location and in the space allocated for it.

D. The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.

E. Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly, and O&M staff shall be able to operate the system prior to turnover.

F. Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

G. Coordinate with the TAB contractor to ensure the specified maximum CFM for the face and bypass coil.

3.2 EQUIPMENT START-UP:

A. Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the Specification Section COMMON WORK RESULTS – HVAC. Refer to Specification Section COMMON WORK RESULTS – HVAC for additional requirements. This equipment is NOT approved to be used for temporary heating and cooling.

3.3 WARRANTY:

A. Provide a 4 year parts and labor warranty

3.4 SERVICE AGREEMENT:

A. Include the following preventative maintenance services for a four (4) year period.
   1. Provide filter inspections quarterly if the differential pressure across the filter exceeds manufacturer's recommendations replace the filter.
   2. Assume 2 filter changes annually for the pre-filters (total 6 changes)
   3. Assume 2 filter changes over the 4 year service agreement for the MERV 13 filters.
   4. Any additional filter change requirements shall be reported to the owner for replacement.

END OF SECTION 237313.13

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SECTION 238239 – ELECTRIC HEATING DEVICES

PART 1 - GENERAL

1.1 SCOPE:

A. This work consists of providing all labor, materials, equipment, and services necessary for the proper installation of electric heat units for the heating, cooling and ventilation system as indicated on the construction documents.

B. All electric elements shall be U.L. approved.

C. Equipment and components principally relevant to this section include:
   1. Electric Wall Heaters
   2. Electric Unit Heaters

PART 2 - PRODUCTS

2.1 ELECTRIC WALL HEATERS:

A. Electric heaters shall consist of galvanized steel casing with architectural grille, fan and motor, and electric coil. Heating element shall consist of metal sheath finned type electric coil with built-in overload protection. Coil shall be complete with magnetic contactor for each circuit. Fan and motor shall be directly connected with continuous fan duty sleeve bearing motor and broad blade aluminum propeller fan. Unit capacity shall be as scheduled on the drawings. Unit heater shall bear the UL label and shall be wired in strict accordance with the NEC.

B. Unit shall be manufactured by Electromode, Markel, Trane or approved equal.

C. Accessories shall include transformer, integral thermostat, power ‘on-off’ switch if so required by National Electrical Code, and wall sleeve.

2.2 ELECTRIC UNIT HEATERS:

A. Electric heaters shall consist of galvanized steel casing with grille, fan and motor, and electric coil. Heating element shall consist of metal sheath finned type electric coil with built-in overload protection. Coil shall be complete with magnetic contactor for each circuit. Fan and motor shall be directly connected with continuous fan duty sleeve bearing motor and broad blade aluminum propeller fan. Unit capacity shall be as scheduled on the drawings. Unit heater shall bear the UL label and shall be wired in strict accordance with the NEC.

B. Unit shall be manufactured by Electromode, Markel, Trane or approved equal.

C. Accessories shall include transformer, integral thermostat, power ‘on-off’ switch if so required by National Electrical Code, and suspension hardware for installation.

PART 3 - EXECUTION

3.1 GENERAL

A. Install wire tracing per manufacturer's specifications. All electric power and control wiring from junction box by mechanical contractor. Junction box by electrical contractor. Coordinate junction box location with electrical contractor.

END OF SECTION 238239

SECTION 239000 - PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 RECORD DRAWINGS:

A. The HVAC contractor shall keep a record copy of the bid set and fabrication drawings at the job site and shall accurately maintain a record with dimensions and elevations of all changes to the contract drawings as the job progresses. At the completion of the job, the HVAC contractor shall submit updated CADD produced mechanical drawings with discs to the Engineer.

B. Show all valve and equipment numbers.

C. Provide complete equipment and piping schematics showing all devices and all thermometers and gauges.

D. Revise all equipment schedules to show actual equipment furnished.

1.2 DEMONSTRATION OF COMPLETE MECHANICAL SYSTEMS:

A. After installation has been completed, equipment has been tested, systems placed in permanent operation, and all adjustments made, a competent start-up technician shall be provided for a period of seven working days. This technician shall operate the system during this time, and during this time shall instruct the Owner's designated representatives in the operation and maintenance of the equipment. The start-up technician shall be at the site continuously during working hours during the instructional period. Systems to be operated include, but are not necessarily limited to:

1.3 COMMISSIONING OF HVAC SYSTEMS:

A. The systems will be commissioned in accordance with ASHRAE Guideline. It shall be the responsibility of this contractor to prepare, conduct, supervise, and implement this effort to the satisfaction of the engineer. As part of this phase of work and included in this contract shall be all non-destructive testing and adjustments requested by the engineer.

B. Operating and Maintenance Manuals:
   1. The form in which the operating maintenance manual is to be presented shall be subject to approval by the Architect. Six copies of the manual shall be provided.
   2. The following items, together with any other necessary and pertinent data, shall be included in the manual. This list is not necessarily complete and is only to be used as a guide.
      a. Suggested settings of all control and switches for normal operation with description of control and its location.

b. A check list for periodic maintenance of all equipment, with maintenance and cleaning instructions.
c. As built wiring, interlock, and control diagrams for the equipment, with color coding shown on wiring and interlock diagrams.
d. Parts list for all replaceable service parts, and indicate where they may be purchased.
e. Manufacturer's cuts and rating tables for all equipment, including copies of all shop drawings.
f. Oiling, lubricating, and greasing data, showing how to lubricate, frequency, and which lubricants to use.
g. Complete electrical load data from operation tests.
h. Test data on all equipment.
i. Belt sizes, types, and lengths.
j. Serial numbers of all principal pieces of equipment.
k. Valve tag schedule (framed).
l. Manufacturers', suppliers, and subcontractors' names, addresses, and telephone numbers.
m. The first page shall identify project and give name, address and phone number of Architect, Engineer, Mechanical and Electrical sub-contractors and any service companies involved and give name and night phone of each party responsible for service.
n. Copies of the valve tag schedule and wiring diagrams shall be framed under glass and posted in the Equipment Room.

1.4 LABELS, IDENTIFICATION AND TAGS:

A. All control components for equipment shall be identified using 3/4" high permanent engraved bakelite nameplates - white letter-black background, with minimum 1/4" high letters. Nameplates shall be permanently attached to device or to wall or mounting panel above device.

B. All equipment including but not limited to compressors, pumps, equipment cabinets shall be identified with yellow 1 inch high letters. Permanent engraved bakelite nameplates - yellow letters - gray background with minimum 1/4 inch high letters. Permanently attach nameplate to equipment.

C. Tag all valves with 1 inch diameter stamped brass tags numbered in sequence. Tags shall also be identified as to the type of piping. Secure with brass chain.

1.5 VALVE TAG SCHEDULE:

A. Copies of the valve tag schedule and wiring diagrams shall be framed under glass and posted in the equipment room.

1.6 SPARE FILTERS:

A. As required in the filter specifications shall be turned over to Owner's representative.

1.7 WARRANTIES:

A. Deliver to Owner all warranties, guarantees, etc. and obtain written receipts.

1.8 PUNCH LIST:

A. During construction period the Engineer will issue punch lists. These items shall be completed before Engineer will approve next application for payment. Final punch list work shall be completed before acceptance.

1.9 FINAL INSPECTION AND ACCEPTANCE:

A. The architect or his authorized representative will entertain the request for final inspection and acceptance only after the following items are done.
   1. Submit a list of uncompleted items, if any, and advise when the items will be done.
   2. Complete all items on Architect's or Engineer's prefinal punch list.
   3. Final inspection and tests of the completed construction shall be performed in the presence of the Architect or his representative and shall be at such times as are convenient to the Architect. Final tests shall show conclusively that all equipment performs its intended and specified function and that all work complies with the provisions of these specifications. All material, equipment, and instruments required for the tests shall be furnished by this HVAC contractor at his own expense.

1.10 FINAL CLEAN UP:

A. During construction this HVAC contractor shall keep the site clear of debris and upon completion of construction he shall clean up the premises and to remove all evidence of his work.

B. The HVAC contractor shall resolve all questionable items to be corrected prior to an inspection by the Engineer. If items have not been corrected completely, and additional site visits are required for the Engineer to check for compliance, the HVAC contractor will be billed by the Owner at $135.00 per hour plus travel expenses for Engineer's services.

1.11 GUARANTEE:

A. The guarantee shall be as stated in the General Conditions, and the General Provisions of this section.

END OF SECTION 239000

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SECTION 239119 - FIXED LOUVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fixed extruded-aluminum louvers.
2. Blank-off panels for louvers

B. Related Requirements:
1. Division 08 – OPENINGS
2. Division 09 - FINISHES

C. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

D. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).

E. Vertical Louver: Louver with vertical blades (i.e., the axis of the blades are vertical).

F. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

G. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing according to AMCA 500-L.

H. Windborne-Debris-Impact-Resistant Louver: Louver that provides specified windborne-debris-impact resistance, as determined by testing according to AMCA 540.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
2. Show mullion profiles and locations.

C. Samples: For each type of metal finish required.

D. Delegated-Design Submittal: For louvers indicated to comply with structural performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

B. Windborne-debris-impact-resistance test reports.

C. Sample Warranties: For manufacturer's special warranties.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.7 WARRANTY

A. Special Finish Warranty: Manufacturer agrees to repair or replace components on which finishes fail in materials or workmanship within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural performance requirements and design criteria indicated.

B. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Structural Drawings.

C. Windborne-Debris-Impact Resistance: Louvers located within 30 feet of grade shall pass enhanced protection, when tested according to AMCA 540.

D. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F, ambient;

F. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Wind-Driven-Rain-Resistant Louver :
1. Louver Depth: 4 inches
2. Frame and Blade Nominal Thickness: Not less than 0.080 inch .
3. Louver Performance Ratings:
   a. Free Area: Not less than 7.0 sq. ft. for 48-inch- wide by 48-inch- high louver.
   b. Air Performance: Not more than static pressure drop at free-area velocity.
   c. Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of at a core-area intake velocity of.
4. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening.

B. Secure screen frames to louver frames with machine screws with heads finished to match louver, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

1. Metal: Same type and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
2. Finish: Same finish as louver frames to which louver screens are attached.
3. Type: Rewirable frames with a driven spline or insert.

D. Louver Screening for Aluminum Louvers:

1. Bird Screening: Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

2.5 BLANK-OFF PANELS

A. Uninsulated Blank-Off Panels: Metal sheet attached to back of louver.
1. Panel Finish: Same finish applied to louvers.
2. Attach blank-off panels with sheet metal screws.

B. Insulated Blank-Off Panels: Laminated panels consisting of an insulating core surfaced on back and front with metal sheets and attached to back of louver.

1. Thickness: 2 inches.
2. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch nominal thickness.
3. Insulating Core: Rigid, glass-fiber-board insulation or extruded-polystyrene foam.
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than 0.080-inch nominal thickness, with corners mitered and with same finish as panels.
5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same finish applied to louvers.
7. Attach blank-off panels with clips sheet metal screws.

2.6 MATERIALS

A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

1. Use tamper-resistant screws for exposed fasteners unless otherwise indicated.
2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.

3. For fastening galvanized steel, use hot-dip-galvanized-steel or 300 series stainless-steel fasteners.
4. For fastening stainless steel, use 300 series stainless-steel fasteners.
5. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Post installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless-steel components, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing according to ASTM E488/E488M conducted by a qualified testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.7 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
2. Horizontal Mullions: Provide horizontal mullions at joints unless continuous vertical assemblies are indicated.

C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

1. Frame Type: Channel unless otherwise indicated.

E. Include supports, anchorages, and accessories required for complete assembly.

F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches o.c., whichever is less.

1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades, so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.

3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
4. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.

G. Provide subsills made of same material as louvers for recessed louvers.

H. Join frame members to each other and to fixed louver blades with fillet welds concealed from view or threaded fasteners unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.8 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

C. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm or thicker.
1. Color: As selected by Architect from full range of industry colors and color densities.

D. Conversion-Coated Finish: AA-C12C42, nonetched, cleaned with inhibited chemicals, and chemical conversion coated with acid chromate-fluoride-phosphate.

E. Factory-Primed Finish: AA-C12C42R1x with air-dried primer of not less than 2-mil dry film thickness.

F. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
1. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required.

3.4 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 239119